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ERRATA.

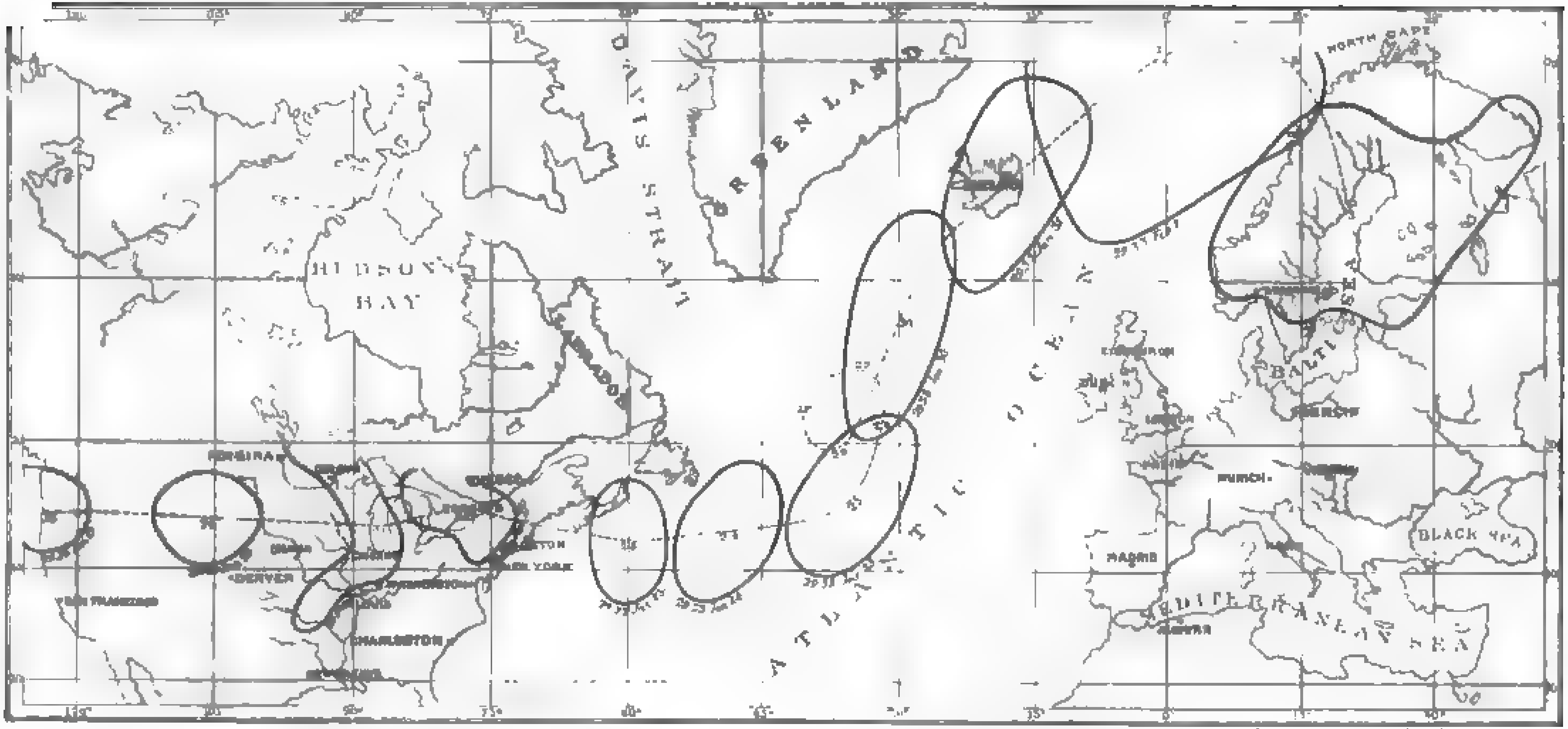
Page 76, line 3 from top, after lines add, of faults; line 5 from top, for streets, read straits; line 2 from foot, for and, read one; line 3 from foot, for Velaine, read Vélain; line 8 from foot, for Mont Alban, read Montalban; line 13 from foot, for feldspar, read feldspars. Page 77, line 11 from foot, for von Hautken, read von Hantken.

Page 317, lines 25, 26 from top, transpose H_2O (comp.) and H_2O (hygr.)

117

JAN 19 FEB

PLATE I.



BAROMETRIC FLUCTUATIONS AT SUMMIT AND BASE OF
MT WASHINGTON MAY 12 TO JUNE 1 1873

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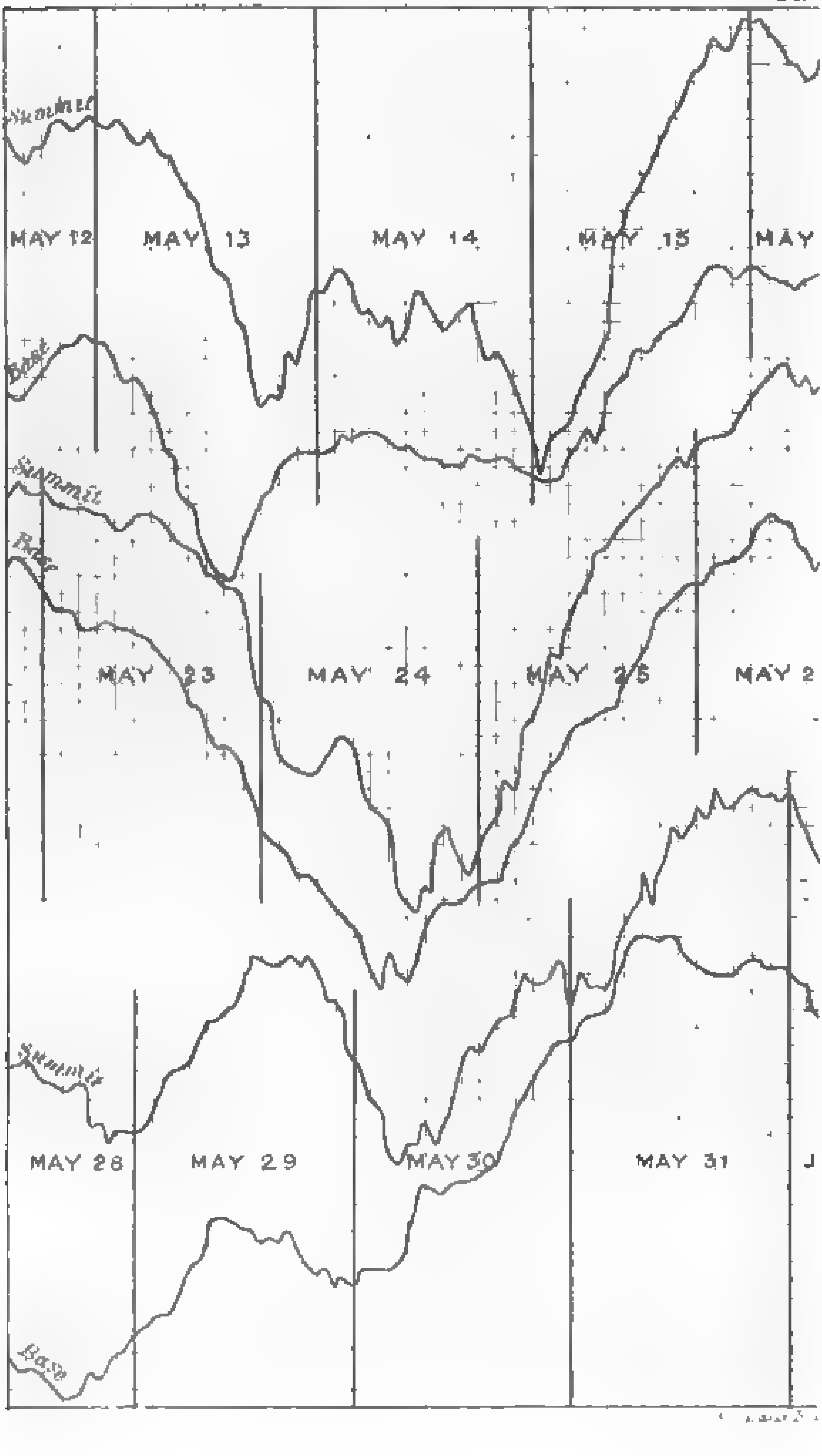

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. I.—*Contributions to Meteorology: being results derived from an examination of the observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Tenth paper. With Plates I and II.

[Read before the National Academy of Sciences, New York, Nov. 6, 1878.]

Storms of the Atlantic Ocean.

IN a former paper, I have noticed some storms which could be traced across the Atlantic Ocean by means of the Paris storm charts from June, 1864, to December, 1865, and Hoffmeyer's charts from December, 1873, to August, 1874. Having received a copy of Hoffmeyer's charts complete to November, 1875, I have undertaken a more careful examination of Atlantic storms. I first provided myself with a large number of blank maps of the Atlantic Ocean, upon precisely the same scale as Hoffmeyer's charts, so that observations could be readily transferred from Hoffmeyer's charts to my own. I then made a careful examination of all the charts in succession. For the first three months (December, 1873, to February, 1874), the isobars are not drawn beyond the meridian of 30° west of Paris, so that these charts were not available for this investigation. For the month of March, 1874, I selected the first chart, which showed an isobar as low as 750 millimeters (29·5 inches), near the coast of the United States, and marked upon one of my maps the position of the center of the lowest isobar. If the same low area could be identified on the chart of the following day, I marked upon my map the position of the center of the lowest isobar for that date, and I did the same for each following day as long as the low area could be identified. The

Storms of the Atlantic Ocean.

No.	Date.	First appearance. Lat.	First appearance. Long.	First appearance. Lowest isobar.	Long. 60°. Lat.	Long. 60°. Lowest isobar.	Long. 30°. Lat.	Long. 30°. Lowest isobar.	Long. 0°. Lat.	Long. 0°. Lowest isobar.	From 60° to 0°. Days.	From 60° to 0°. Aver. velocity	On English Coast. Highest wind.	On English Coast. Direc'n of wind.
	1874.													
1	Mar. 4	46°·5	75°·5	745										
2	8	47·0	77·1	750	48°·1	745	60°·7	740	68°·7	735	2·8	36·4	4	S.W.
3	20	47·0	61·3	740	49·2	740	65·0	730	72·5	745	4·0	24·8	4	W.N.W.
4	23	53·5	55·0	740	51·4	740	63·2	735	61·8	750	14·6	6·5	3	S.W.
5	April 3	48·6	70·6	750	52·3	750	62·6	745	48·5	740	9·2	12·0	5	W.N.W.
6	12	46·4	63·5	750										
7	15	51·8	74·0	750	50·0	750	60·2	745	67·7	745	6·1	15·8	4	S.
8	21	47·0	75·0	750										
9	26	41·5	72·2	745	44·5	740								
10	30	46·5	71·3	740	44·0	750								
11	May 26	47·0	76·7	750	55·0	750	59·4	745	66·4	755	6·7	12·8	3	W.
12	June 1	43·0	69·3	745										
13	8	48·0	72·0	750	44·5	750								
14	13	50·5	75·0	750	47·8	755								
15	18	44·2	71·8	750										
16	23	52·5	70·0	750	49·1	750								
17	29	45·0	80·0	750										
18	July 8	47·8	71·8	750										
19	16	45·6	71·8	750										
20	Aug. 1	47·5	75·5	745										
21	Sep. 11	49·5	56·4	750										
22	30	45·6	71·8	740										
23	Oct. 11	51·5	71·4	745	59·6	750	61·9	740	68·5	740	7·8	9·6	5	W.
24	18	51·9	68·0	745	54·5	750	64·6	730	69·6	730	5·7	13·8	4	S.W.
25	28	37·0	62·0	750	38·2	750	38·2	755						
26	30	51·3	71·0	750	54·4	755	64·0	740	68·0	740	3·3	22·6	3	S.W.
27	Nov 10	46·6	56·0	745	50·8	745	69 0	745	62·0	740	5·1	16·1	4	N.W.
28	21	44·2	67·8	745	43·3	750								
29	24	48·0	70·0	735										
30	29	46·0	72·7	750										
31	Dec. 9	52·7	56·0	750	49·8	750								
32	15	50·0	59·0	750	49·3	750	62·6	745	64·6	755	9·7	10·2	5	S.W.
33	21	40·0	65·5	750	39·2	755								
34	25	47·4	57·7	740	47·7	740	59·0	735	59·3	740	9·3	11·1	4	S.W.
	1875.													
35	Jan. 3	46·8	60 8	735	47·4	735	59·5	735	61·4	740	13·3	7·7	3	S.W.
36	8	43·5	65·0	740										
37	10	45·4	58·0	750	45·8	750	*	*	*	*	6·0	17·6	3	S.W.
38	14	43·4	66·0	750	47·6	745	58·3	740	61·5	735	5·0	21·1	4	S.W.
39	23	42 8	62·0	750	43·2	750	59·5	740	68·6	740	9·0	12·6	3	S.
40	25	44·5	68·7	750	49·7	745	†	†	†	†	6·5	14·9	3	S.
41	30	43·0	63·6	750	43·0	750	56·8	745	68·5	750	16·3	6·9	3	S.W.
42	Feb. 1	41·5	63·0	745	44·7	745	‡	‡	‡	‡	14·1	7·7	3	S.W.
43	8	40·5	64·5	740	43·6	745	‡	‡	‡	‡	7·0	16·0	3	S.W.
44	12	47·6	66·3	740	59·0	740								
45	20	45·0	84·3	750										
46	26	46·5	64·0	750	51·0	735	47·3	725	73·0	740	10·5	9·1	5	W.
47	Mar. 7	39·8	57·2	750	41·5	750								
48	8	40·5	67·0	745	42·3	745	†	†	†	†				
49	17	46·0	68·0	745	53·2	740	63·2	720	67·6	745	9·3	9·5	4	W.
50	25	42·4	68·4	745	60·4	745	64·8	755	63·7	740	7·7	10·1	4	W.

Storms of the Atlantic Ocean.

		First appearance.			Long. 60°		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
No.	Date.	Lat.	Long.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Days.	Aver. velocity	Highest wind.	Direct'n of wind.
	1875.													
[illegible]	April 6	38·0	53·0	750	40·5	750	45·2	740	48·5	755	16·4	7·4	3	E.
52	14	41·5	72·3	750	40·6	750	†	†	†	†	7·4	16·3	3	[illegible]
53	16	45·0	77·3	750	45 3	745	50·2	740	72·8	745	14·1	7·7	3	S.
54	25	39·7	60 0	750	39·7	750	†	†	†	†	9 8	12·6	3	S.
55	30	46·5	77·2	745	47 3	750	47 0	750						
56	May 2	50·0	78 6	740	63·0	750	62·4	745	†	†	†	†		
57	5	42·5	57·5	750	†	†	†	†						
58	7	41·4	67·5	750	41·0	750	54·0	745	67·7	750	7·0	17·0	3	W.
59	12	45·0	83·5	750										
60	Jun. 17	39·9	58·4	750	40·0	750								
61	19	43 2	63 8	745	53·8	745	61·4	745						
62	28	48 5	73 5	750	53·8	750	62·3	750						
63	July 17	43 3	66 6	750	44·3	750								
64	25	44·8	59·7	750	44 7	750								
65	30	40·4	67·7	750										
66	Sept. 4	47 4	77·5	750	62·0	750								
67	17	42·5	73·0	750	46·3	745	44·6	735	58·7	730	[illegible]	12·0	5	W.
68	26	48·3	60·0	750	48·3	750	65·0	740						
69	Oct. 2	50·0	63·0	750	51·8	750	59·6	740	66·7	735	3 2	28·7	3	W.
70	16	47·6	66·2	750	56 8	745	53·4	735	47·8	755	9·9	10·5	4	E. to W.
71	21	44·2	65 7	745	42·7	750	†	†	†	†	7·0	16·[illegible]	4	E. to W.
72	25	40 0	64 4	750	40·0	745	49 6	745	64·4	745	10·2	11·7	3	W.
73	28	48·6	63 5	750	48 3	750	†	†	†	†	7 2	13 9	3	W.
74	31	43·7	72·0	740	45·3	740	52·4	750	52 0	725	8·9	12 4	5	N.W.
75	Nov 11	43 5	69·6	735	45 9	740	53·8	745	56·8	755	6·0	17·9	4	W.
76	17	46·6	64 7	725	47 5	740								
77	29	47 3	70·0	750	48·8	740								
	Means			746	49 6	746	58 0	74[illegible]	63·3	743	8 5	14 0		

* This low area appeared to coalesce with No. 35.
† This low area appeared to coalesce with the low next preceding.

points thus determined were connected by straight lines, and the probable track of the low area was thus obtained. The same method was pursued with each of the charts to November 30, 1875. I thus obtained seventy-seven cases of low areas near the coast of the United States, and was able to follow thirty-six of them with considerable confidence entirely across the Atlantic Ocean; but eight of these storms became merged in other storms before reaching the European coast, leaving only twenty-eight different low areas which reached the coast of Europe. The preceding table exhibits the most important particulars relating to these seventy-seven cases. Column 1st contains the number for reference; column 2d shows the date of the chart upon which a low area was first found near the coast of the United States; column 3d shows the latitude, and

Storms of the Atlantic Ocean.

No.	Date.	First appearance.			Long. 60°.		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
		Lat.	Long.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Days.	Aver. velocity	Highest wind.	Direc'n of wind.
	1874.													
1	Mar. 4	46°·5	75°·5	745										
2	8	47·0	77·1	750	48°·1	745	60°·7	740	68°·7	735	2·8	36·4	4	S.W.
3	20	47·0	61·3	740	49·2	740	65·0	730	72·5	745	4·0	24·8	4	W.N.W.
4	23	53·5	55·0	740	51·4	740	63·2	735	61·8	750	14·6	6·5	3	S.W.
5	April 3	48·6	70·6	750	52·3	750	62·6	745	48·5	740	9·2	12·0	5	W.N.W.
6	12	46·4	63·5	750										
7	15	51·8	74·0	750	50·0	750	60·2	745	67·7	745	6·1	15·8	4	S.
8	21	47·0	75·0	750										
9	26	41·5	72·2	745	44·5	740								
10	30	46·5	71·3	740	44·0	750								
11	May 26	47·0	76·7	750	55·0	750	59·4	745	66·4	755	6·7	12·8	3	W.
12	June 1	43·0	69·3	745										
13	8	48·0	72·0	750	44·5	750								
14	13	50·5	75·0	750	47·8	755								
15	18	44·2	71·8	750										
16	23	52·5	70·0	750	49·1	750								
17	29	45·0	80·0	750										
18	July 8	47·8	71·8	750										
19	16	45·6	71·8	750										
20	Aug. 1	47·5	75·5	745										
21	Sep. 11	49·5	56·4	750										
22	30	45·6	71·8	740										
23	Oct. 11	51·5	71·4	745	59·6	750	61·9	740	68·5	740	7·8	9·6	5	W.
24	18	51·9	68·0	745	54·5	750	64·6	730	69·6	730	5·7	13·8	4	S.W.
25	28	37·0	62·0	750	38·2	750	38·2	755						
26	30	51·3	71·0	750	54·4	755	64·0	740	68·0	740	3·3	22·6	3	S.W.
27	Nov 10	46·6	56·0	745	50·8	745	69 0	745	62·0	740	5·1	16·1	4	N.W.
28	21	44·2	67·8	745	43·3	750								
29	24	48·0	70·0	735										
30	29	46·0	72·7	750										
31	Dec. 9	52·7	56·0	750	49·8	750								
32	15	50·0	59·0	750	49·3	750	62·6	745	64·6	755	9·7	10·2	5	S.W.
33	21	40·0	65·5	750	39·2	755								
34	25	47·4	57·7	740	47·7	740	59·0	735	59·3	740	9·3	11·1	4	S.W.
	1875.													
35	Jan. 3	46·8	60 8	735	47·4	735	59·5	735	61·4	740	13·3	7·7	3	S.W.
36	8	43·5	65·0	740										
37	10	45·4	58·0	750	45·8	750	*	*	*	*	6·0	17·6	3	S.W.
38	14	43·4	66·0	750	47·6	745	58·3	740	61·5	735	5·0	21·1	4	S.W.
39	23	42 8	62·0	750	43·2	750	59·5	740	68·6	740	9·0	12·6	3	S.
40	25	44·5	68·7	750	49·7	745	†	†	†	†	6·5	14·9	3	S.
41	30	43·0	63·6	750	43·0	750	56·8	745	68·5	750	16·3	6·9	3	S.W.
42	Feb. 1	41·5	63·0	745	44·7	745	‡	‡	‡	‡	14·1	7·7	3	S.W.
43	8	40·5	64·5	740	43·6	745	‡	‡	‡	‡	7·0	16·0	3	S.W.
44	12	47·6	66·3	740	59·0	740								
45	20	45·0	84·3	750										
46	26	46·5	64·0	750	51·0	735	47·3	725	73·0	740	10·5	9·1	5	W.
47	Mar. 7	39·8	57·2	750	41·5	750								
48	8	40·5	67·0	745	42·3	745	†	†	†	†				
49	17	45·0	68·0	745	53·2	740	63·2	720	67·6	745	9·3	9·5	4	W.
50	25	42·4	68·4	745	60·4	745	64·8	755	63·7	740	7·7	10·1	4	W.

Storms of the Atlantic Ocean.

No.	Date.	First appearance. Lat.	First appearance. Long.	First appearance. Lowest isobar.	Long. 60°. Lat.	Long. 60°. Lowest isobar.	Long. 30°. Lat.	Long. 30°. Lowest isobar.	Long. 0°. Lat.	Long. 0°. Lowest isobar.	From 60° to 0°. Days.	From 60° to 0°. Aver. velocity	On English Coast. Highest wind.	On English Coast. Direct'n of wind.
	1875.													
51	April 6	38°·0	53°·0	750	40°·5	750	45°·2	740	48°·5	755	16·4	7·4	3	E.
52	14	41·5	72·3	750	40·6	750	†	†	†	†	7·4	16·3	3	E.
53	16	45·0	77·3	750	45·3	745	60·2	740	72·8	745	14·1	7·7	3	S.
54	25	39·7	60·0	750	39·7	750	†	†	†	†	9·8	12·6	3	S.
55	30	46·5	77·2	745	47·3	750	47·0	750						
56	May 2	50·0	78·6	740	53·0	750	62·4	745	†	†	†	†		
57	5	42·5	67·5	750	†	†	†	†						
58	7	41·4	67·5	750	41·0	750	54·0	745	67·7	750	7·0	17·0	3	W.
59	12	45·0	83·5	750										
60	Jun 17	39·9	58·4	750	40·0	750								
61	19	43·2	68·8	745	53·8	746	61·4	745						
62	28	48·5	73·6	750	53·8	750	62·3	750						
63	July 17	43·3	66·6	750	44·3	750								
64	25	44·8	59·7	750	44·7	750								
65	30	40·4	67·7	750										
66	Sept. 4	47·4	77·5	750	62·0	750								
67	17	42·5	73·0	750	46·3	745	44·6	735	58·7	730	8·8	12·0	5	W.
68	26	48·3	60·0	750	48·3	750	65·0	740						
69	Oct. 2	50·0	63·0	750	51·8	750	59·6	740	66·7	735	3·2	28·7	[illegible]	W.
70	16	47·6	66·2	750	56·8	745	53·4	735	47·8	755	9·9	10·5	4	E. to W.
71	21	44·2	55·7	745	42·7	750	†	†	†	†	7·0	16·[illegible]	4	E. to W.
72	25	40·0	64·4	750	40·0	745	49·6	745	64·4	745	10·2	11·7	3	W.
73	28	48·6	63·5	750	48·3	750	†	†	†	†	7·2	13·9	3	W.
74	31	43·7	72·0	740	45·3	740	52·4	750	52·0	725	8·9	12·4	5	N.W.
75	Nov 11	43·5	69·6	735	45·9	740	53·8	745	56·8	755	6·0	17·9	4	W.
76	17	46·6	64·7	725	47·5	740								
77	29	47·3	70·0	750	48·8	740								
	Means			746	49·6	746	58·0	74[illegible]	63·3	743	8·5	14·0		

* This low area appeared to coalesce with No. 35.
† This low area appeared to coalesce with the low next preceding.

points thus determined were connected by straight lines, and the probable track of the low area was thus obtained. The same method was pursued with each of the charts to November 30, 1875. I thus obtained seventy-seven cases of low areas near the coast of the United States, and was able to follow thirty-six of them with considerable confidence entirely across the Atlantic Ocean; but eight of these storms became merged in other storms before reaching the European coast, leaving only twenty-eight different low areas which reached the coast of Europe. The preceding table exhibits the most important particulars relating to these seventy-seven cases. Column 1st contains the number for reference; column 2d shows the date of the chart upon which a low area was first found near the coast of the United States; column 3d shows the latitude, and

Storms of the Atlantic Ocean.

No.	Date.	First appearance. Lat.	Long.	Lowest isobar.	Long. 60°. Lat.	Lowest isobar.	Long. 30°. Lat.	Lowest isobar.	Long. 0°. Lat.	Lowest isobar.	From 60° to 0°. Days.	Aver. velocity	On Eu[ropean] Coa[st] Highest wind.	Direc'n
	1874.													
1	Mar. 4	46°·5	75°·5	745										
2	8	47·0	77·1	750	48°·1	745	60°·7	740	68°·7	735	2·8	36·4	4	S.
3	20	47·0	61·3	740	49·2	740	65·0	730	72·5	745	4·0	24·8	4	W.
4	23	53·5	55·0	740	51·4	740	63·2	735	61·8	750	14·6	6·5	3	S.
5	April 3	48·6	70·6	750	52·3	750	62·6	745	48·5	740	9·2	12·0	5	W.
6	12	46·4	63·5	750										
7	15	51·8	74·0	750	50·0	750	60·2	745	67·7	745	6·1	15·8	4	[illegible]
8	21	47·0	75·0	750										
9	26	41·5	72·2	745	44·5	740								
10	30	46·5	71·3	740	44·0	750								
11	May 26	47·0	76·7	750	55·0	750	59·4	745	66·4	755	6·7	12·8	3	[illegible]
12	June 1	43·0	69·3	745										
13	8	48·0	72·0	750	44·5	750								
14	13	50·5	75·0	750	47·8	755								
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16	23	52·5	70·0	750	49·1	750								
17	29	45·0	80·0	750										
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19	16	45·6	71·8	750										
20	Aug. 1	47·5	75·5	745										
21	Sep. 11	49·5	56·4	750										
22	30	45·6	71·8	740										
23	Oct. 11	51·5	71·4	745	59·6	750	61·9	740	68·5	740	7·8	9·6	5	[illegible]
24	18	51·9	68·0	745	54·5	750	64·6	730	69·6	730	5·7	13·8	4	S.
25	28	37·0	62·0	750	38·2	750	38·2	755						
26	30	51·3	71·0	750	54·4	755	64·0	740	68·0	740	3·3	22·6	3	S.
27	Nov 10	46·6	56·0	745	50·8	745	69 0	745	62·0	740	5·1	16·1	4	N.
28	21	44·2	67·8	745	43·3	750								
29	24	48·0	70·0	735										
30	29	46·0	72·7	750										
31	Dec. 9	52·7	56·0	750	49·8	750								
32	15	50·0	59·0	750	49·3	750	62·6	745	64·6	755	9·7	10·2	5	S.
33	21	40·0	65·5	750	39·2	755								
34	25	47·4	57·7	740	47·7	740	59·0	735	59·3	740	9·3	11·1	4	S.
	1875.													
35	Jan. 3	46·8	60 8	735	47·4	735	59·5	735	61·4	740	13·3	7·7	3	S.
36	8	43·5	65·0	740										
37	10	45·4	58·0	750	45·8	750	*	*	*	*	6·0	17·6	3	S.
38	14	43·4	66·0	750	47·6	745	58·3	740	61·5	735	5·0	21·1	4	S.
39	23	42 8	62·0	750	43·2	750	59·5	740	68·6	740	9·0	12·6	3	[illegible]
40	25	44·5	68·7	750	49·7	745	†	†	†	†	6·5	14·9	3	[illegible]
41	30	43·0	63·6	750	43·0	750	56·8	745	68·5	750	16·3	6·9	3	S.
42	Feb. 1	41·5	63·0	745	44·7	745	†	†	†	†	14·1	7·7	3	S.
43	8	40·5	64·5	740	43·6	745	†	†	†	†	7·0	16·0	3	S.
44	12	47·6	66·3	740	59·0	740								
45	20	45·0	84·3	750										
46	26	46·5	64·0	730	51·0	735	47·3	725	73·0	740	10·5	9·1	5	[illegible]
47	Mar. 7	39·8	57·2	750	41·5	750								
48	8	40·5	67·0	745	42·3	745	†	†	†	†				
49	17	46·0	68·0	745	53·2	740	63·2	720	67·6	745	9·3	9·5	4	[illegible]
50	25	42·4	68·4	745	60·4	745	64·8	755	63·7	740	7·7	10·1	4	[illegible]

Storms of the Atlantic Ocean.

		First appearance.			Long. 60°.		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
No.	Date.	Lat.	Long.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Days.	Aver. velocity	Highest wind.	Direct'n of wind.
	1875.													
51	April 6	38°0	53°0	750	40°5	750	45°2	740	48°5	755	16·4	7·4	[illegible]	[illegible]
52	14	41·5	72·3	750	40·6	750	†	†	†	†	7·4	16·3	3	E.
53	16	45·0	77·3	750	46·3	745	50·2	740	72·8	745	14·1	7·7	3	S.
54	25	39·7	60·0	750	39·7	750	†	†	†	†	9·8	12·6	3	S.
55	30	46·5	77·2	745	47·3	750	47·0	750						
56	May 2	50·0	78·6	740	53·0	750	62·4	745	†	†	†	†		
57	5	42·5	57·5	750	†	†	†	†						
58	7	41·4	67·5	750	41·0	750	54·0	745	67·7	750	7·0	17·0	3	W.
59	12	45·0	83·5	750										
60	Jun. 17	39·9	58·4	750	40·0	750								
61	19	43·2	68·8	745	53·8	745	61·4	745						
62	28	48·5	73·6	750	53·8	750	62·3	750						
63	July 17	43·3	66·6	750	44·3	750								
64	25	44·8	59·7	750	44·7	750								
65	30	40·4	67·7	750										
66	Sept 4	47·4	77·5	750	62·0	750								
67	17	42·5	73·0	750	46·3	745	44·6	735	58·7	730	8·8	12·0	5	W.
68	26	48·3	60·0	750	48·3	750	65·0	740						
69	Oct. 2	50·0	63·0	750	61·8	750	59·6	740	66·7	735	3·2	28·7	3	W.
70	16	47·6	66·2	750	56·8	745	53·4	735	47·8	755	9·9	10·5	4	E. to W.
71	21	44·2	65·7	745	42·7	750	†	†	†	†	7·0	16·[illegible]	4	E. to W.
72	25	40·0	64·4	750	40·0	745	49·6	745	64·4	745	10·2	11·7	3	W.
73	28	48·6	63·5	750	48·3	750	†	†	†	†	7·2	13·9	3	W.
74	31	43·7	72·0	740	45·3	740	52·4	750	52·0	725	8·0	12·4	6	N.W.
75	Nov 11	43·5	69·6	745	45·9	740	53·8	745	56·8	755	6·0	17·9	4	W.
76	17	46·6	64·7	725	47·5	740								
77	29	47·3	70·0	750	48·8	740								
	Means			746	49·6	746	58·0	74[illegible]	63·3	743	8·5	14·0		

* This low area appeared to coalesce with No. 35.
† This low area appeared to coalesce with the low next preceding.

points thus determined were connected by straight lines, and the probable track of the low area was thus obtained. The same method was pursued with each of the charts to November 30, 1875. I thus obtained seventy-seven cases of low areas near the coast of the United States, and was able to follow thirty-six of them with considerable confidence entirely across the Atlantic Ocean; but eight of these storms became merged in other storms before reaching the European coast, leaving only twenty-eight different low areas which reached the coast of Europe. The preceding table exhibits the most important particulars relating to these seventy-seven cases. Column 1st contains the number for reference; column 2d shows the date of the chart upon which a low area was first found near the coast of the United States; column 3d shows the latitude, and

column 4th the longitude of the center of the lowest isobar for the date mentioned in column 2d, and column 5th shows the amount of the lowest isobar. As the isobars are drawn at intervals of five millimeters, it is probable that at the center of the low area the pressure was frequently as low as 745 m. (29·3 inches), and sometimes lower. Column 6th shows the latitude in which the central path of the low area crossed the meridian of 60° W. from Paris, and column 7th shows the lowest isobar for that position; column 8th shows the latitude in which the central path crossed the meridian of 30° W. of Paris, and column 9th shows the lowest isobar for that position; column 10th shows the latitude in which the central path crossed the meridian of Paris, and column 11th shows the lowest isobar in that position; column 12th shows the number of days required for the low center to travel from the meridian of 60° to that of Paris; and column 13th shows the average velocity of the center in its course between these two meridians. This average is obtained by supposing the center to have followed the arc of a great circle, and takes no account of the actual irregularities of its course. Column 14th shows the highest wind reported on the English coast at the time the low center was nearest. These winds are estimated upon a scale from 1 to 6, where 1 denotes a light breeze; 2 a fresh breeze; 3 very fresh; 4 a hard wind; 5 a gale, and 6 denotes a hurricane. The velocities given in column 14th are the highest velocities reported anywhere near the coast of England, but do not include Scotland. If Scotland had been included, the velocities in some cases would have been greater. Column 15th shows the direction of the wind corresponding to the velocity in column 14th. Sometimes at several stations the same velocity was reported, but with different directions. The direction given in column 15th is the one which occurs most frequently for the given date and velocity.

We see from this table that in one year there are on an average only eighteen different storms which can be traced by means of Hoffmeyer's charts from the coast of the United States across the Atlantic. If for each day we had two good charts, instead of only one, it is probable that a few more storms might be identified in their progress across the ocean, but it is doubtful whether the number would be greatly increased. Nearly all of these storms pursued a course north of east, and passed considerably to the north of Scotland. In only four of the cases did the low center cross the meridian of Paris in a latitude as low as the northern boundary of England. The average track of the thirty-six low centers which are traced across the ocean, is shown by the means at the bottom of the table, where it is seen that the meridians of 60°, 30° and 0°,

were crossed in the latitudes 49°·6, 58°·0 and 63°·3. Since the storm centers generally passed 800 miles north of London, most of them did not exhibit much violence on the English coast. In half of the cases, the highest velocity reported was 3, denoting a very fresh breeze, and in only six of the cases was the velocity at any station on the English coast as high as 5, denoting a gale.

We may hence conclude that when a center of low pressure (below 29·5 inches) leaves the coast of the United States, the probability that it will pass over any part of England is only one in nine; the probability that it will give rise to a gale anywhere near the English coast is only one in six; and the probability that it will give rise to a very fresh breeze is one in two.

One of the most noticeable circumstances connected with Atlantic storms is their slow rate of progress. This is due partly to the erratic course of the center of the low area, and partly to the frequent blending of two low areas into one, whence it generally results that the most eastern center appears to be pushed backward toward the west. In my eighth paper I have described a remarkable example of this kind of movement. In like manner the storms numbered 35, 39, 41, 51, 53, 70 and 72 of the preceding table appeared to be pushed westward by blending with storms of a subsequent date. Aside from this cause of detention, there seems in the Atlantic Ocean to be a special cause which frequently holds storms nearly stationary in position from day to day, and this cause is probably the abundance of warm vapor rising from the Gulf Stream, in close proximity to the cold dry air from the neighboring coast of North America. Hence we see that when American storms are predicted to appear upon the European coast, and it is assumed that they will cross the ocean at the same rate as they have crossed the United States, such predictions will seldom be verified.

It will also be noticed that the storms which cross the Atlantic, generally increase in intensity after leaving the American coast; the average depression of the barometer shown in the preceding table being 6 millimeters (0·24 inch) greater in long. 30° than in long. 60°.

Origin of the storms here traced.—Two of the storms enumerated in the preceding table and which have been traced across the Atlantic (Nos. 51 and 70), appear to have originated over the Atlantic Ocean; five of them (Nos. 46, 52, 54, 73 and 75), appear to have originated in Texas or its vicinity; four of them (Nos. 67, 69, 71 and 74), appeared to originate in the middle latitudes, but considerably east of the Rocky Mountains; about half of the whole number appear to have originated in the neighborhood of the Rocky Mountains; that is, it is diffi-

cult to trace them satisfactorily further west; but four of the number can be distinctly traced to the Pacific coast, viz: two of them (Nos. 26 and 41) to California, and two of them (Nos. 39 and 40) to Oregon. The course of No. 39 is represented on Plate I. At 7.35 A. M., January 19th, the barometer at Portland, Oregon, stood at 29·34, and at 4.35 P. M. at 29·22, a depression which has seldom been observed at that place. This low area traveled eastward across the United States with diminishing intensity. On the morning of the 20th, the greatest depression was at Bismark, 29·48; on the morning of the 21st, at Keokuk, 29·75; on the 22d, at Alpena, 29·74; on the 23d, at Sydney, 29·54, and during the next two days the depression still further increased. Another low area had now arrived at Nova Scotia, and on the 26th had approached so near the former that the two seemed inclined to coalesce. On the two following days this tendency became more decided, and on the 29th both were united in one great depression, the pressure near the center being 28·94. This low area advanced toward the northeast without any perceptible diminution of intensity; but when it had nearly reached the North Cape, its course was turned to the southeast. The center of this low area has thus been traced through about 150° of longitude, and considering that the depression was unusually great when first observed in Oregon, it seems safe to conclude that this low area preserved its identity through more than 180° of longitude. It will be seen, however, that this storm of January 19th to February 3d, 1875, was an unusual case. The changes of the barometric depressions are so frequent that a low area can seldom be identified in its progress from the Pacific Ocean to Eastern Europe.

West India Cyclones.—During the period embraced by Hoffmeyer's maps, there occurred several cyclones which originated in or near the Gulf of Mexico. The following cases are noted on the maps of the United States Signal Service:

1.	1874, Sept. 5- 7.	4.	1875, Sept. 14–19.
2.	" Sept. 9-11.	5.	" Oct. 13–16.
3.	" Sept. 27–30.	6.	" Nov. 8–11.

No. 1 apparently moved northward and was merged in a larger depression previously existing near South Greenland. No. 2 cannot be certainly identified on the map of September 12th. No. 3 apparently moved northward over Labrador. No. 4 (the great Indianola hurricane) appeared to merge in a greater depression previously existing near Newfoundland, without producing any sensible modification in it. No. 5 can be traced across the Atlantic, but during its progress it blended with one or two other depressions. No. 6 can be traced across the Atlantic, and throughout the entire passage preserved its identity pretty

ıctly. Thus we see that of the six cyclones here men-d, only two can be traced across the Atlantic, and only ɔf them escaped blending with another depression. These (although few in number) suggest the conclusion that the t India cyclones, however violent they may be within the cs, when they reach the middle latitudes, expand in area lose much of their violence, and after a few days are lly merged in some of the larger depressions which gen- ŗ prevail in some part of the North Atlantic Ocean.

ʻuations of the barometer on Mt. Washington and Pike's Peak.

ıe Annual Report of the United States Chief Signal Officer 873 contains a series of hourly observations of the barom- ɔn the summit of Mt. Washington (elevation 6,285 feet), also at the base of the mountain (elevation 2,898 feet) ıg May and June, 1873. I have projected all these obser- ıns in curve lines and find a general correspondence between luctuations of the barometer at the two stations, with some led differences, among which the most noticeable is that naxima and minima of pressure generally occur earlier at ɔase of the mountain than they do at the summit. The wing table shows the principal maxima and minima for months of May and June, the barometric readings being ected for temperature and instrumental error only.

Barometer at base and summit of Mt. Washington.

	Date.	Base.		Summit.		Diff.
Min.	May 3	12 M.	26·820	2 P.M.	23·390	+2h.
Max.	8	7 A.M.	27·547	11 A.M.	24·114	+4
Min.	13	2 P.M.	26·654	6 P.M.	23·147	+4
Max.	21	8 A.M.	27·480	9 A.M.	24·055	+1
Min.	24	1 P.M.	26·822	5 P.M.	23·422	+4
Max.	26	8 A.M.	27·346	9 A.M.	24·029	+1
Min.	28	4 P.M.	26·988	9 P.M.	23·631	+5
Max.	29	10 A.M.	27·187	5 P.M.	23·839	+7
Min.	30	12 P.M.	27·114	5 A.M.	23·607	+5
Max.	31	9 A.M.	27·500	4 P.M.	24·021	+7
Min.	June 5	2 A.M.	26·756	5 A.M.	23·406	+3
Max.	8	6 P.M.	27·388	6 P.M.	24·040	0
	9	5 A.M.	27·393	11 A.M.	24·012	+6
Min.	11	6 A.M.	27·007	9 A.M.	23·670	+3
Max.	13	4 A.M.	27·430	10 A.M.	24·043	+6
Min.	17	2 A.M.	26·952	4 A.M.	23·540	+2
Max.	18	8 A.M.	27·138	12 M.	23·748	+4
Min.	20	2 A.M.	26·788	4 A.M.	23·468	+2
Max.	25	10 A.M.	27·582	12 M.	24·270	+2
Min.	28	4 A.M.	26·983	5 P.M.	23·708	+13

ɜveral of these maxima and minima are represented on Plate The upper curve represents the barometric fluctuations on

the summit of the mountain from May 12, 2 P. M., to May 16, 2 P. M., the interval between the horizontal lines representing a difference of one-fiftieth inch pressure, and the interval between the vertical lines representing two hours of time. The second curve represents the barometric fluctuations at the base of the mountain for the same dates. The third and fourth curves represent the fluctuations from May 22, 8 P. M., to May 26, 8 P. M.; and the fifth and sixth curves represent the fluctuations from May 28, 10 A. M., to June 1, 10 A. M. The minimum of May 13th is pretty sharply defined, and occurred on the summit four hours later than at the base. On the morning of May 15th occurred another minimum, which at the summit was sharply defined, but at the base was inconsiderable. The minimum of May 24th was pretty sharply defined at both stations, and the same is true of the maximum May 26th. From May 28th to June 1st occurred two minima and two maxima which are not very sharply defined, but the critical points at the summit evidently lag behind the corresponding points at the base. The maximum of June 8th continued for twenty-four hours with but little change, and the highest reading occurred at the summit of the mountain earlier than at the base, which may be regarded as an exception to the general rule. If, however, we compare the corresponding undulations of the two curves, I think it will appear that the first maximum occurred at both stations at about the same instant, and the second maximum occurred six hours earliest at the base. The decided fall of the barometer began six hours earlier at the base than at the summit. The minimum of June 28th continued for eighteen hours without much change, but the absolute minimum occurred thirteen hours earlier at the base than at the summit.

These observations appear to me to prove that the maxima and minima of the barometer do not generally occur simultaneously at the top and bottom of Mt. Washington, but on an average occur more than three hours later at the summit than at the base, showing an average retardation of one hour for each 900 feet of elevation.

In order to test this result by independent observations, I compared the observations made on the summit of Mt. Washington with those made at Burlington, Vt., and Portland, Me., from September, 1872, to January, 1875. Burlington and Portland are distant from each other about 150 miles, and Mt. Washington is about midway between them, and we might expect that the barometric minima at Mt. Washington would occur at dates intermediate between those at Burlington and Portland. I therefore selected all those cases in which the barometer at Portland fell as low as 29·6 inches, and deter-

mined the times of barometric minima at these three stations. The result is shown in the following table, where the numeral 1 following a date denotes the 7.35 A. M. observation; 2 denotes the 4.35 P. M. observation; and 3 denotes the 11 P. M. observation. When the pressure at two successive observations was sensibly the same, I have taken the intermediate date as being the true time of minimum. The fifth column shows the difference between the date of minimum on Mt. Washington and the half sum of the dates at Burlington and Portland expressed in units of eight hours.

Barometric minima at Burlington, Vt., Portland, Me., and Mt. Washington, N. H.

	Burl'n.	Portl'd.	Mt. W.	Diff.		Burl'n.	Portl'd.	Mt. W.	Diff.
1872.	d.	d.	d.		1873.	d.	d.	d.	
Oct.	14.1½	14.1½	14.2	+0·5	Dec.	26.3	26.3	26.3	0·0
	27.1	27.1	27.1	0·0		28.1	28.1	28.2	+1·0
Nov.	7.1	7.2	7.3	+1·5	1874.				
	12.2	12.3	12.3	+0·5	Jan.	8.2	8.2	8.2½	+0·5
	14.3	14.3½	15.1	+0·7		10.1	10.2	10.2	+0·5
	30.1	30.1	30.1	0·0		15.2	15.2½	16.1	+1·7
Dec.	2.3	3.1	3.1	+0·5		23.1	23.2	23.2	+0·5
	9.1	9.3	10.1	+2·0		28.1	28.2	28.3	+1·5
	27.2	27.2	28.1	+2·0	Feb.	10.2½	10.3	11.1½	+1·7
1873.						13.3	14.1	14.1	+0·5
Jan.	3.3	3.3	4.1	+1·0		16.2	16.3	17.1	+1·5
	5.3	5.3	6.1	+1·0	March	4.1	4.2	4.2	+0·5
	21.3	22.1	22.1	+0·5		9.1	10.1½	10.1	+1·2
	27.2	27.3	27.3	+0·5		19.2	19.3	20.1½	+2·0
Feb.	4.2	4.2	4.2½	+0·2		22.3	23.1	23.1	+0·5
	8.1	8.1	8.2	+1·0		26.2	26.3	26.3	+0·5
	21.2½	21.3	22.2	+1·2	April	3.1	3.2	3.2	+0·5
March	3.2	3.2	3.3	+1·0		15.2	15.2	16.1	+2·0
	8.2½	9.1	9.1	+0·7		21.1	21.1	21.1½	+0·5
	16.1	16.1½	16.3	+1·7		26.1	26.1	26.1	0·0
	21.1½	21.1½	21.2½	+1·0		30.2	30.1	30.2	+0·5
	23.2	23.3	24.1	+1·5	May	5.2½	5.2	5.3½	+1·2
	26.2	26.3	27.1	+1·5		25.2½	25.3	25.3½	+0·7
	29.3	30.1	30.1	+0·5		31.2½	31.2½	32.1	+1·5
	31.1	31.2	31.2	+0·5	June	7.3½	8.1	8.2	+1·2
April	14.2	14.2	14.1	−1·0		17.2½	17.3½	17.3½	+0·5
	19.1½	19.2	19.3	+1·2		23.2	23.3	24.1	+1·5
	25.3½	26.1½	26.1	0·0		28.2	28.2	28.3	+1·0
May	13.1	13.2	13.2	+0·5	Aug.	1.2	1.2	1.2	0·0
	24.1½	24.2	24.2	+0·2	Sept.	30.1	30.1	30.2	+1·0
June	4.2½	4.2½	4.3½	+1·0	Oct.	2.2	2.2	2.3	+1·0
	19.3	20.2	20.2	+1·0		10.2½	10.3	11.1	+1·2
Sept.	1.2	1.2	2.1	+2·0		17.3½	18.2	18.3½	+2·2
Oct.	7.1	7.1	7.1	0·0	Nov.	10.3½	11.1½	11.3	+2·0
	12.1	12.2	12.3	+1·5		20.3	20.3	21.1	+1·0
	27.1	27.2	27.2	+0·5		23.3	23.3	23.3½	+0·5
Nov.	8.2	8.2	8.3	+1·0		29.1½	29.1½	29.2	+0·5
	12.3	12.3	13.1½	+1·5	Dec.	17.2	17.3	18.1	+1·5
	18.2	18.2	18.2	0·0		24.1½	24.2	24.2	+0·2
Dec.	4.1	4.2	4.2½	+1·0	1875.				
	13.2	13.3	13.3	+0·5	Jan.	2.2	2.2	2.3	+1·0

It will be seen that in one instance the minimum at Mt. Washington occurred earlier than it did at Burlington or Portland; in eight cases the minima occurred simultaneously; in seventy cases the minimum on Mt. Washington occurred later than the half sum of the dates at Burlington and Portland, the average difference being 0·88, or seven hours. The height of Mt. Washington above Burlington and Portland is 6,148 feet, showing an average retardation of one hour for an elevation of 870 feet.

I next compared the observations made at the summit of Mt. Mitchell in North Carolina (elevation 6,691 feet) with those made at the base of the mountain (elevation 2,560 feet) from August 6th to September 5th, 1873, published in the Report of the United States Chief Signal Officer for 1873, but the fluctuations of the barometer were too small to yield satisfactory results. The following are the most noticeable coincidences of minimum pressure:

	Base.	Summit.	Difference.
1873. Aug. 13	3 P.M.	4 P.M.	+1 hour.
15	2 A.M.	5 A.M.	+3 hours.
25	5 P.M.	7 P.M.	+2
27	2 A.M.	4 A.M.	+2
Sept. 4	3 P.M.	7 P.M.	+4
5	3 P.M.	6 P.M.	+3

These results indicate an average retardation of one hour for an elevation of 1,600 feet, but the fluctuations are so small that no great importance can be attached to them except as they are taken in connection with other observations.

I next compared the observations made on Pike's Peak (elevation 13,960 feet) with those made at Colorado Springs, the base of the mountain (elevation 5,830 feet), a copy of which observations I have received in manuscript through the kindness of General Myer. When the observations at these two stations are projected in curves, the differences between the two curves are seen to be considerable, but there is a large number of cases in which the resemblance is very decided. The following table contains those cases in which the dates of maximum and minimum pressure are most sharply defined. There are many other cases in which the general resemblance of the curves is very decided, but the change of curvature is too gradual to admit of a satisfactory comparison of the instants of maximum or minimum pressure. The table shows the date (hour and minute) of several maxima and minima both at Colorado Springs and Pike's Peak, and the last column shows the difference between the dates of the critical points at the two stations.

Barometer at Colorado Springs and Pike's Peak.

	Date.	Colorado Springs.		Pike's Peak.		Diff.
		h. m.	barom.	h. m.	barom.	h. m.
ax.	1873. Nov. 16	10.25 A.M.	30·15	4.25 P.M.	30·12	+ 6.10
in.	22	7.35 A.M.	29·69	7.35 A.M.	29·64	0.00
in.	Dec. 2	3.52 P.M.	29 48	3. 7.35 A.M.	29·18	+15.43
in.	7	4.35 P.M.	29·58	7.47 P.M.	29·47	+ 3.12
in.	11	4.35 P.M.	29·60	4.35 P.M.	29·48	0.00
ax.	13	8.13 A.M.	30·27	7.47 P.M.	30·18	+11.34
ax.	24	8.13 A.M.	30·27	11.00 P.M.	30·12	+14.47
in.	25	11.00 P.M.	29·80	26. 7.35 A.M.	29·75	+ 8.35
in.	1874. Jan. 3	7.35 A.M.	29 28	4.35 P.M.	29·32	+ 9.00
ax.	6	12.00 M.	30·17	7.47 P.M.	30·03	+ 7.47
in.	26	4.35 P.M.	29·71	27. 7.35 A.M.	29·65	+15.00
ax.	28	8.13 A.M.	30·19	11.00 P.M.	30·07	+14.47
ax.	Feb. 8	12.00 M.	30·12	9. 7.35 A.M.	29·93	+19.35
in.	12	10.25 A.M.	29·31	4.35 P.M.	29·20	+ 6.10
ax.	19	11.00 P.M.	29·81	11.00 P.M.	29·64	0.00
in.	March 5	11.00 P.M.	29·43	4.35 P.M.	29·36	— 6.25
in.	30	4.13 P.M.	29·65	4.35 P.M.	29·58	+ 0.22
ax.	April 2	8.52 A.M.	30·19	4.35 P.M.	29·95	+ 7.43
in.	4	4.13 P.M.	29·63	4.35 P.M.	29·60	+ 0.22
in.	May 1	4.35 P.M.	29·50	2. 7.35 A.M.	29·50	+15.00
in.	9	3.52 P.M.	29·39	4.35 P.M.	29·46	+ 0.43
ax.	Oct. 21	11.00 P.M.	30·28	22. 12.00 M.	30·27	+13.00
in.	24	7.35 A.M.	29·64	7.35 A.M.	29·63	0.00
ax.	26	12.00 M.	30·21	4.35 P.M.	30·11	+ 4.35
in.	28	7.35 A.M.	29·59	3.17 A.M.	29·63	— 4.18
ax.	30	11.00 P.M.	30·31	11.00 P.M.	29·98	0.00
ax.	Nov. 12	12.00 M.	30·16	4.35 P.M.	30·06	+ 4.35
in.	22	7.35 A.M.	29·32	7.35 A.M.	29·37	0.00
ax.	25	1.25 A.M.	29·98	7.35 A.M.	29·95	+ 6.10
in.	Dec. 15	4.35 P.M.	29·58	7.47 P.M.	29·56	+ 3.12
ax.	23	11.00 P.M.	30·08	11.00 P.M.	29·79	0.00
ax.	1875. Jan. 21	4.35 P.M.	30·03	11.00 P.M.	29·76	+ 6.25
in.	22	11.00 P.M.	29·75	23. 7.35 A.M.	29·54	+ 8.35

majority of the cases, the critical points occur several ater on Pike's Peak than at Colorado Springs. In ten :ases the difference was less than one hour, and in two he minimum appeared to occur earlier at the summit the base of the mountain. These anomalies are, how- ore apparent than real. In No. 16 the barometer at Peak was lowest at 4.35 P. M., but at 7.35 A. M. of the ıy it had risen only 0·02 inch. In No. 25, at the time minimum at Colorado Springs, the barometer at Pike's ad not yet begun to rise, so that we may claim that in these cases the minima occurred sensibly at the same at both stations. The average retardation indicated by cases in the table is $5^h\ 50^m$, or one hour for an elevation 0 feet.

number of cases here examined appears to be sufficient rant the following conclusions: that over the United both the maxima and minima of atmospheric pressure

generally occur first near the surface of the earth, and they occur later as we rise above the surface, the retardation amounting to one hour for an elevation of from 900 to 1,300 feet.

Since the changes in the pressure of the air generally begin at the surface of the earth, it might be presumed that the changes in the direction of the wind must follow the same law. In order to decide this question I selected all those cases in which the wind on the summit of Mt. Washington blew from either the points S., S.E., E. or N.E., according to the hourly observations during the months of May and June, 1873. The number of these cases was 196, and they belong to ten different periods whose duration is shown in column 3d of the following table. Column 2d shows the direction of the wind during this period, and column 4th shows the number of hours at which this wind was observed.

Comparison of winds at the base and summit of Mt. Washington.

No.	On the summit of Mt. Washington.			Surface winds from the East.	
	Wind.	Duration.	H'rs.	Began.	Ended.
1	S. to E.	May 2, 2 P.M. to May 3, 6 P.M.	29	7 h'rs earliest.	4 h'rs latest.
1	S. to E.	May 9, 1 A.M. to May 10, 4 P.M.	40	11 " "	2 " earliest.
3	S.	May 11, 11 A.M. to May 12, 5 A.M.	19	12 " "	8 " earliest.
4	S.	May 21, 11 A.M. to May 21, 4 P.M.	6	12 " "	5 " earliest.
5	S.	May 26, 10 A.M. to M. 26, 11 A.M.	2	Uncertain.	Uncertain.
6	S.E. to N.E.	June 7, 7 P.M. to June 10, 11 A.M.	46	Variable.	Variable.
7	N.E.	June 13, 2 A.M. to June 13, 8 A.M.	4	6 hr's earliest.	Uncertain.
8	S. to S.E.	June 14, 1 P.M. to June 15, 1 A.M.	10	6 " "	2 h'rs latest.
9	S.E. to N.E.	June 22, 9 P.M. to June 25, 3 P.M.	36	Simultaneous.	Variable.
10	S.	June 29, 6 P.M. to June 29, 9 P.M.	4	Simultaneous.	Variable.

In the case of Nos. 6, 7, 8 and 9 the interval named in column 3d exceeds the number of hours mentioned in column 4th, and includes several hours of calms, besides a few hours in which there was a feeble wind from the N. or W. points. Column 5th shows when the surface winds began to blow from S., S.E., E. or N.E.; and column 6th shows when these winds changed to north or west. The time here given for the change of the surface winds is designed to indicate the time of general change at the neighboring stations, and does not depend exclusively upon observations at the base of the mountain. It will be seen that the surface winds generally began to blow from the east several hours before the change took place on the summit of Mt. Washington. The change of wind back from east to west sometimes occurred first at the base and sometimes it occurred first on the summit. The term *variable* in column 6th denotes that the surface winds were feeble, and fluctuated for several hours between east and west.

It will be noticed that during the entire period of the baro-

metric oscillations represented on Plate II, the wind on Mt. Washington never blew from the S., S.E., E. or N.E., and the same is true of the four minima in the months of May and June, 1873, mentioned on page 9. Thus we see that areas of low barometer frequently occur accompanied by surface winds from the south and east, while the winds on Mt. Washington blow uninterruptedly from the western quarter; and in those cases in which the wind on Mt. Washington blows from an eastern quarter, the change from west to east generally occurs first at the base of the mountain.

It is also noticeable that the diurnal movements of the barometer exhibit a peculiarity similar to that found for the accidental fluctuations. This is shown by the following table,

Mean height of the barometer at all hours of the day.

	Mount Washington, New Hampshire.								Mt. Mitchell, N. C.	
	Month of June.				Month of May.		May and June.		August.	
	Stat'n 1	Stat'n 2	Stat'n 3	Stat'n 4	Stat'n 1	Stat'n 4	Sum't.	Base.	Sum't.	Base.
1 A.M.	23·818	24·512	25·979	27·179	23·702	27·152	23·760	27·165	23·720	27·355
2	·815	·513	·975	·173	·699	·149	·757	·161	·714	·351
3	·806	·508	·971	·170	·696	·147	·751	·158	·711	·347
4	·802	·511	·976	·175	·690	·146	·746	·160	·706	·349
5	·805	·513	·982	·181	·701	·150	·753	·165	·713	·357
6	·811	·513	·987	·189	·701	·158	·756	·173	·720	·368
7	·817	·520	·993	·196	·707	·164	·762	·180	·731	·373
8	·821	·527	·996	·196	·714	·166	·767	·181	·739	·378
9	·828	·532	·998	·196	·718	·166	·773	·181	·748	·379
10	·838	·536	·999	·196	·725	·165	·781	·180	·753	·374
11	·838	·533	·997	·190	·731	·162	·784	·176	·753	·363
noon	·841	·532	·992	·182	·733	·156	·787	·169	·746	·354
1 P.M.	·839	·532	·985	·177	·731	·149	·785	·163	·737	·345
2	·834	·527	·985	·171	·732	·143	·783	·157	·730	·333
3	·830	·528	·976	·161	·725	·142	·777	·152	·726	·330
4	·825	·521	·973	·158	·725	·142	·775	·150	·719	·321
5	·817	·520	·973	·152	·724	·147	·771	·150	·717	·323
6	·822	·517	·973	·156	·721	·154	·771	·155	·717	·329
7	·818	·523	·976	·165	·727	·162	·772	·163	·723	·345
8	·818	·522	·980	·166	·727	·166	·773	·166	·730	·360
9	·826	·531	·984	·173	·733	·170	·779	·171	·737	·361
10	·823	·522	·983	·172	·727	·170	·775	·171	·739	·861
11	·821	·522	·981	·174	·720	·169	·770	·171	·736	·360
midn't	·815	·516	·978	·169	·716	·165	·765	·167	·728	·355

which gives the results derived from the hourly observations published in the Signal Service Report for 1873. Column 2d shows the mean height of the barometer at station 1 (summit of Mt. Washington), at each hour of the day for the month of June. Column 3d shows the mean height of the barometer at station 2 (5,553 feet above sea level); column 4th shows the barometer at station 3 (4,058 feet above the sea); and column

5th shows the barometer at station 4 (2,898 feet above the sea). Columns 6th and 7th show the mean height of the barometer at stations 1 and 4 for the month of May; columns 8th and 9th show the mean height of the barometer at stations 1 and 4 for the months of May and June combined. Column 10th shows the mean height of the barometer at each hour of the day for the month of August, on the summit of Mt. Mitchell, N. C. (elevation 6,691 feet), and column 11th shows the barometer at the base of the mountain (elevation 2,560 feet).

At the base of Mt. Washington the principal maximum occurs at 8½ A. M., but on the summit it does not occur until noon, being a retardation of 3½ hours, which is almost identically the same as we have found on page 7 by a comparison of the accidental fluctuations. At the base of Mt. Mitchell the principal maximum occurs at 8¼ A. M., but on the summit it occurs at 10¼ A. M., being a retardation of two hours, which also accords remarkably with the result derived on page 10, from the accidental fluctuations.

High Winds on Mount Washington.

In order to study the laws of the winds on Mount Washington, I selected from the published volumes of the Signal Service observations (Sept., 1872 to Jan., 1875) all those cases in which the velocity of the wind was at least sixty miles per hour. The number of these cases was 434, of which 117 occurred at 7.35 A. M., 137 at 4.35 P. M. and 180 at 11 P. M. Thus we see that at 11 P. M. the frequency of high winds is 42 per cent greater than at the other hours of observation. But near the level of the sea the force of the wind at 11 P. M. is generally near its minimum, so that we conclude that the causes which produce high winds on Mount Washington are mainly independent of the causes which determine the ordinary diurnal change in the force of the wind near the level of the sea.

The following table shows the average number of cases of violent winds for each month of the year.

Spring.			Summer.			Autumn.			Winter.		
Mar.	17.5		June	11.5		Sept.	11.7		Dec.	22.7	
Apr.	15.5	14.0	July	6·5	9.2	Oct.	9.7	13.8	Jan.	21.3	21.2
May	9.0		Aug.	9.5		Nov.	20.0		Feb.	19.5	

Thus we see that during the winter months, high winds are twice as frequent as during the summer months, while near the level of the sea high winds are seven times as frequent during the former period as during the latter period.

The following table shows the number of cases in which the wind blew from the different directions at the time of these high velocities.

North,	53	cases.	South,	14	cases.
Northwest,	260	"	Southeast,	8	"
West.	63	"	East.	2	"
Southwest,	27	"	Northeast,	7	"

hus we see that 60 per cent of all the high winds came from northwest; 75 per cent came from the west and northwest; per cent came from the west, northwest and north; while r 4 per cent came from the northeast, east and southeast.

n order to determine whether these high winds bear a con- t relation to centers of low pressure as indicated by obser- ons near the level of the sea, I prepared a table showing each date the position of the nearest center of low pressure. s table is so large that I have not thought it expedient to lish it entire, and I have endeavored to abridge it in such a ner as to give a correct idea of the contents of the complete e. In order to equalize the number of examples for the rent directions of the wind, I adopted a different standard velocity for each direction of the wind. For the northwest ds I have employed only velocities amounting to one hundred s per hour; for the west wind, I have employed velocities of ty miles per hour; for the north winds velocities of seventy- miles; for the southwest winds sixty-five miles; for the th sixty miles; for the southeast, fifty-four miles; for the heast, fifty miles, and for the east winds I have employed all cities amounting to forty miles per hour. The results are wn in the following table, in which column 1st shows the num- of reference, column 2d shows the date of observation; col- n 3d the direction of the wind, column 4th its velocity in es per hour, column 6th the position of the nearest center of pressure, and column 5th the height of the barometer at station named.

t will be observed that with a north wind of seventy-five es per hour on Mount Washington there was generally a center near Halifax, Chatham, Sydney or Cape Rozier. In ne cases the center of least pressure had already passed ond our stations of observation. This remark applies to s. 1, 12 and 13. The direction of the wind was nearly at ht angles to the direction of the low center. In all these es the pressure was above thirty inches on the west side of unt Washington and at a distance of five hundred or six dred miles; but in a majority of the cases the center of h pressure was southwest of Mount Washington.

Vith a northwest wind of one hundred miles per hour on unt Washington there was generally a low center near Hali- Sydney, Quebec, Father Point or Cape Rozier. In the e of No. 33 (which is the continuation of No. 11) the low er had already passed beyond our stations of observation.

High Winds on Mt. Washington.

No.	Date.	Wind. Direc.	Wind. Vel.	Low. Bar.	Low. Station.	No.	Date.	Wind. Direc.	Wind. Vel.	L… Bar.	
1	'73. Jan. 11.3	N.	76	29·95	Halifax.	62	'74. Oct. 29.2	S.W.	68	29·49	A
2	'74. April 4.3	N.	96	·45	Sydney.	63	Dec. 11.1	S.W.	70	·79	O
3	11.3	N.	103	·69	Chatham.	64	'75. Jan. 9.1	S.W.	73	·72	P
4	Sept. 2.1	N.	80	·68	Sydney.	65	13.2	S.W.	65	·64	P
5	Oct. 16.1	N.	80	·77	C. Rozier.	66	'73. Jan. 5.2	S.	64	·45	B
6	19.3	N.	90	·37	Chatham.	67	6.3	S.	60	·34	O
7	20.1	N.	90	·56	Chatham.	68	8.3	S.	66	·40	M
8	Nov. 11.1	N.	78	·50	C. Rozier.	69	13.3	S.	80	·68	M
9	11.3	N.	80	·31	C. Rozier.	70	Mar. 11.2	S.	77	·41	M
10	12.1	N.	76	·50	C. Rozier.	71	31.3	S.	82	·63	P
11	29.2	N.	84	·30	Chatham.	72	April 9.3	S.	69	·47	M
12	Dec. 12.2	N.	100	·96	C. Rozier.	73	'74. Apr. 20.2	S.	60	·40	R
13	12.3	N.	80			74	May 18.1	S.	68	·55	S
14	15.2	N.	75	·75	Sydney.	75	18.3	S.	60	·69	Q
15	'75. Jan. 23.2	N.	96	·65	Sydney.	76	June 16.1	S.	60	·70	O
16	26.3	N.	98	·40	C. Rozier.	77	Nov. 20.2	S.	60	·38	P
17	27.2	N.	98	·48	Halifax.	78	28.3	S.	70	·85	A
18	'73. Feb. 10.2	N.W.	103	·56	Halifax.	79	'75. Jan. 24.2	S.	[illegible]	·63	B
19	Mar. 8.3	N.W.	126	35	Quebec.	80	'72. Dec. 3.2	S.E.	60	·58	Q
20	Aug. 16.3	N.W.	100	·63	Quebec.	81	8·2	S.E.	54	·47	M
21	'74. Jan. 25.3	N.W.	126	·88	Halifax.	82	'73. Mar. 20.3	S.E.	84	·36	T
22	Feb. 5.2	N.W.	100	·67	Sydney.	83	Aug 14.2	S.E.	60	·78	L
23	8.1	N.W.	108	·62	Sydney.	[illegible]	14.3	S.E.	60	·82	P
24	11.2	N.W.	100	28·84	Sydney.	85	18.2	S.E.	60	·90	P
25	Mar. 20.3	N.W.	110	29·33	C. Rozier.	86	Oct. 20.1	S.E.	75	·45	O
26	23.3	N.W.	130	·49	Sydney.	87	20.2	S.E.	78	·26	P
27	24.3	N.W.	102	78	Sydney.	88	21.1	S.E.	55	·28	E
28	Apr. 30.2	N.W.	130	28·97	Father Pt.	89	Nov. 17.3	S.E.	66	28·82	C
29	30.3	N.W.	116	·99	Father Pt.	90	'74. Jan. 8.1	S.E.	62	29·32	O
30	June 12.3	N.W.	100	29·58	Quebec.	91	Sept. 17.3	S.E.	58	·56	P
31	13.3	N.W.	108	·76	Sydney.	92	Nov. 23.1	S.E.	54	28·75	A
32	Nov. 5.3	N.W.	100	·64	Quebec.	93	'72. Oct. 7.1	[illegible]	[illegible]	29·83	O
33	30.3	N.W.	100			94	Dec. 6.1	E.	42	·95	Q
34	Dec. 30.3	N.W.	100	·59	C. Rozier.	[illegible]	'73. Apr. 12.3	E.	96	·61	N.
35	'75. Jan. 9.3	N.W.	100	·28	Halifax.	96	May 3.2	E.	[illegible]	·68	N
36	'72. Nov. 25.2	W.	85	·39	Quebec.	97	9.2	E.	48	·61	G
37	Dec. 10.3	W.	84	·73	Quebec.	98	Nov. 18.1	E.	48	28·66	N
38	'73. Dec. 4.2	W.	80	·43	Quebec.	99	[illegible]	E.	68	29·27	B
39	4.3	W.	96	·29	Chatham.	100	'74. Apr. 10.1	E.	52	·49	C
40	'74. Jan. 23.2	W.	80	·32	Father Pt.	101	25.3	E.	68	·32	C
41	23.3	W.	108	·27	C. Rozier.	102	26.1	E.	90	·13	B
42	24.1	W.	88	·77	C. Rozier	103	May 21.3	E.	60	·63	P
43	Feb. 25.3	W.	90	·47	Father Pt.	104	July 4.3	E.	44	·72	N
44	Mar. 24.2	W.	115	·67	Sydney.	105	Sept. 29.3	[illegible]	64	·24	N.
45	June 8.1	W.	90	·45	Quebec.	106	Oct. 8.3	[illegible]	50	·81	B
46	Oct. 29.3	W.	92	·57	Montreal.	107	'72. Oct. 31.2	N.E.	50	·91	N
47	Nov. 5.2	W.	82	·67	Father Pt.	108	31.3	N.E.	72	·79	P
48	Dec. 14.3	W.	94	·28	Sydney.	109	Dec. 10.2	N.E.	62	[illegible]	Q
49	18.1	W.	80	·18	Halifax	110	20.1	N.E.	55	·43	B
50	'72. Nov. 12.2	S.W.	65	72	Montreal.	111	20.2	N.E.	52	·50	M
51	Dec. 21.3	S.W.	65	·88	Oswego.	112	28.1	N.E.	60	·49	H
52	'73. Jan. 16.2	S.W.	74	·45	Buffalo.	113	28.2	N.E.	55	·81	H
53	16.3	S.W.	72	·36	Quebec.	114	28.3	N.E.	72	·94	H
54	Sept. 25.3	S.W.	65	·81	Montreal.	115	29.1	N.E.	54		
55	Nov. 27.2	S.W.	72	·55	Father Pt.	116	'73. Feb. 17.1	N.E.	60	·63	N
56	Dec. 4.1	S.W.	65	28·91	Marquette	117	24.1	N.E.	52	·24	Q
57	'74. Jan. 4.3	S.W.	80	29·55	Father Pt.	118	Apr. 12.2	N.E.	70	·52	[illegible]
58	7.1	S.W.	65	·53	Ft. Garry.	119	13.1	N.E.	58	·61	B
59	Feb. 23.1	S.W.	82	·58	Rochester.	120	Oct. 8.2	N.E.	50	·69	H
60	Mar. 3.3	S.W.	96	33	Erie.	121	8.3	N.E.	60	·91	N
61	4.1	S.W.	74	·34	Ottawa.						

twelve of the cases the stations which show the lowest pres-
e are the same as reported above for the north winds, but in
of the cases the lowest pressure was farther to the west.
e average direction of the low center from Mount Washing-
was nearly at right angles to the direction of the winds.
all of these cases (except Nos. 28 and 29) the pressure was
ve thirty inches on the west side of Mount Washington
l generally at a distance of about five hundred miles, but in
ajority of the cases the center of high pressure was south-
st of Mount Washington.
With a west wind of eighty miles per hour, the low center
s generally near some one of the stations already named.
six of the cases the low center was near one of the stations
ned for the north winds; in twelve of the cases the low
ter was near one of the stations named for the northwest
ds; and in one case (No. 46) the low center was farther
st than was found for the north or northwest winds. The
gle which the wind's direction made with the direction of
station reporting the least pressure ranges from about zero
somewhat over 90°. On account of the small number of
tions, it is generally impossible to assign exactly the position
the center of least pressure, but apparently the angle which
wind's direction made with the direction of the low center
s in some cases less than 45°. In all of these cases (except
s. 45 and 47) the pressure was above thirty inches on the
st side of Mount Washington and generally at a distance of
ut eight hundred miles; but in all cases the center of high
ssure was somewhat south of west from Mount Washington.
With a southwest wind of sixty-five miles per hour, the
ection of the station reporting the lowest pressure ranges
m N. 25° E. to S. 75° W., the average direction of the low
ter making an angle of about 90° with the direction of the
d. In the case of No. 58 there was a low center in Vir-
ia and a low center at the same time in Manitoba, and both
med to exert an influence upon the direction of the wind on
unt Washington. In six of these cases the center of high
ssure was southwest of Mount Washington, but in the
naining ten cases its direction was almost exactly west, and
distance about 1,300 miles.
With a south wind of sixty miles per hour on Mount
ashington the low center is generally found nearly west from
t station. The exceptions are Nos. 71, 75, 77 and 78. In
case of seventy-one we find the pressure at Montreal was
s than at Burlington, so that it appears possible that at the
ght of 6,000 feet the center of least pressure was not over
rtland but northwest of Montreal. In the case of seventy-
e the pressure at Ottawa was only ·07 inch greater than at

Quebec; in the case of seventy-seven the pressure at Kingston was only ·02 inch greater than at Portland; and in seventy-eight the pressure at Albany was only ·05 inch greater than at Atlantic City; so that it appears not improbable that at the height of 6,000 feet the center of least pressure at each of these four dates was west of Mount Washington. In each of these cases there was a center of high pressure in a direction west or southwest from Mount Washington and at an average distance of 1,100 miles. It is presumed there was also an area of high pressure on the east side of Mount Washington, but it had already passed beyond our stations of observation.

With a southeast wind of fifty-four miles per hour on Mount Washington the low center falls between the directions south and northwest. The only exception is No. 80 and this case seems to indicate that at the height of 6,000 feet the low center was nearly two hundred miles in arrears of the low center at the surface of the earth. In each of these cases there was an area of high pressure west or southwest of Mount Washington. Generally its direction was nearly west and its distance about 1,200 miles. The center of high pressure on the east side had generally passed beyond our stations of observation, but in the case of No. 91, the pressure at Cape Rozier was 30·67 inches, and the distance of the center of low pressure was more than twice as great as usual.

With an east wind of sixty miles per hour the low center is generally found nearly south of Mount Washington. The exceptions are Nos. 93, 94, 97 and 103. In the case of Nos. 93 and 97, observations at other stations place the low center considerably south of Oswego and Grand Haven; and in the case of No. 103, observations at other stations place the low center west of Portland. The position of the areas of high pressure is nearly the same as for the southeast winds.

With a northeast wind of fifty miles per hour the low center is generally found south or southeast of Mount Washington. The exceptions are Nos. 109, 110, 111 and 117. In the case of Nos. 109 and 117 no observations were made near the Atlantic coast at any station east of Portland, and it is probable that at these dates the low center was not far from Halifax. In the case of Nos. 110 and 111 the low center came from the southwest, and the minimum of pressure on Mount Washington occurred fifteen hours later than at Burlington or Portland. It seems probable therefore that at the height of 6,000 feet the low center was considerably southwest of its position at the surface of the earth. In the case of No. 115 the low center had already passed beyond Halifax, which was the most eastern station of observation.

The examination of these one hundred and twenty-one cases

ems to warrant the following conclusions: 1. High winds on ount Washington circulate about a low center as they do ar the level of the sea. 2. The motion of the wind is arly at right angles to the direction of the low center. 3. he low center at the height of Mount Washington sometimes gs behind the low center at the surface of the earth apparatly as much as two hundred miles.

High Winds on Pike's Peak.

In order to study the laws of the winds on Pike's Peak, I lected from the published volumes of the Signal Service oservations (November, 1873 to January, 1875) all those cases which the velocity of the wind was as great as thirty miles er hour. The number of these cases was 363, of which 136 ere reported at 7.35 A. M., 97 at 4.35 P. M., and 130 at 11 P. M. ence it appears that at 4.35 P. M. high winds are twenty-five er cent less frequent than at the other two hours of observaon. But near the level of the sea the average force of the ind at 4 P. M. is double that at the other two hours, which sults accord with the Mt. Washington observations in indicatig that these high winds are mainly independent of the causes hich determine the diurnal change at the level of the sea.

The average number of cases of violent winds for each onth of the year is as follows:

Spring.			Summer.			Autumn.			Winter.		
March	14	15.7	June	21	11.3	Sept.	17	26.5	Dec.	28.5	31.2
April	17		July	2		Oct.	24		Jan.	42	
May	16		Aug.	11		Nov.	38.5		Feb.	23	

Thus we see that during the winter months high winds are early three times as frequent as during the summer months.

The following table shows the number of cases in which the ind blew from the different directions at the time of these igh velocities.

North,	28 cases.	South,	18 cases.
Northwest,	47 "	Southeast,	1 case.
West,	154 "	East,	0 "
Southwest,	111 "	Northeast,	4 cases.

'hus we see that seventy-three per cent of these high winds ome from the west and southwest, and only one per cent comes om any easterly point.

In order to determine whether these high winds bear a contant relation to centers of low pressure near the level of the a, I have prepared a table similar to that on page 16. For e west winds I have employed all velocities amounting to fty-five miles per hour; for the southwest winds I have nployed velocities of fifty miles per hour; for the northwest inds velocities of forty-two miles per hour; for the north inds thirty-five miles per hour; for the south winds thirty-

two miles per hour; for the northeast winds twenty-two miles per hour; for the southeast winds ten miles per hour, and for the east winds I have employed all velocities amounting to seven miles per hour. The following table is arranged in the same manner as that on page 16. For No. 47 the velocity of the wind is given seventy-seven miles according to the published observations; but I am informed by General Myers that this velocity should be thirty miles.

It will be observed that with a north wind of thirty-five miles per hour on Pike's Peak, there was generally an area of low pressure on the east side of that station. In the case of No. 11, throughout the entire United States the barometer was above thirty inches, but a low center was forming near Mobile which on the next day developed into a storm of considerable intensity. We also find that there was generally an area of high pressure in a direction west or northwest from Pike's Peak.

With a northwest wind of forty-two miles per hour, there was generally an area of low pressure on the northeast side of Pike's Peak. No. 23 is the same case as No. 11 noticed above. We also find that there was generally an area of high pressure on the Pacific coast.

With a west wind of fifty-five miles per hour, there was generally an area of low pressure in a northeast direction from Pike's Peak, and an area of high pressure on the Pacific coast. No. 40 is the same case as Nos. 11 and 23 noticed above.

With a southwest wind of fifty miles per hour, there was generally an area of low pressure in a northerly direction from Pike's Peak, and an area of high pressure on the Pacific coast or on the coast of Texas.

With a south wind of thirty-two miles per hour, there was generally an area of low pressure in a northerly direction from Pike's Peak. Frequently the center of low pressure appeared to be in a direction east of north. If there had been more westerly stations of observation it is presumed that in some of these cases the center of least pressure would have been found west of Bismark and Fort Sully. In the case of No. 73 an area of low pressure was forming near Pike's Peak, which became fully developed the next day. We also find that the pressure was generally somewhat above the mean in a direction southeast from Pike's Peak.

With a southeast wind of not less than ten miles per hour, there was generally an area of low pressure at no great distance, but in half of the cases the lowest observed pressure was on the northeast side of Pike's Peak. All but three of the cases occurred in summer, and the average velocity of the wind was only sixteen miles per hour. We also find that on the east side of Pike's Peak, the pressure was in each case a little above thirty inches.

High Winds on Pike's Peak.

Date.	Wind. Direc.	Wind. Vel.	Low. Bar.	Low. Station.	No.	Date.	Wind. Direc.	Wind. Vel.	Low. Bar.	Low. Station.
3. Nov. 17.3	N.	35	29·27	St. Louis.	62	'74. Apr. 12.1	S.	32	29·49	Ft. Sully.
18.2	N.	35	·33	Augusta.	63	May 27.3	S.	48	·24	Ft. Sully.
Dec. 26.1	N.	40	·41	Escanaba.	64	July 17.3	S.	32	·65	Ft. Sully.
26.3	N.	40	·48	Detroit.	65	Aug. 25.1	S.	40	·82	Salt Lk. C.
'4. Jan. 6.1	N.	40	·90	Montgom.	66	Oct. 22.3	S.	32	·82	Bismark.
May 2.3	N.	40	·35	Leavenw.	67	23.3	S.	40	·65	Salt Lk. C.
3.1	N.	36	[redacted]	Leavenw.	[redacted]	24.1	S.	[redacted]	·66	Salt Lk. C.
Aug. 3.3	N.	36	·82	Ft. Sully.	69	24.3	S.	60	·24	Bismark.
Nov. 24.3	N.	55	·75	N Orleans.	70	26.2	S.	40	·89	Salt Lk. C.
25.1	N.	35	·74	Jacksonv.	71	26.3	S.	50	·88	Salt Lk. C.
26.1	N.	35			72	27.3	S.	68	·64	Cheyenne.
Dec. 17.3	N.	40	·65	Santa Fé.	73	Nov. 15.3	S.	38		
21.3	N.	45	·62	St. Paul.	74	Dec. 14.2	S.	32	·87	Bismark.
23.2	N.	45	·49	Marquette	75	25.2	S.	40	·78	Salt Lk. C
'3. Nov. 17.1	N W.	65	·41	Duluth.	76	27.2	S.	32	·59	Bismark.
'4. Jan. 7.1	N W.	[redacted]	·53	Ft. Garry.	77	'75. Jan. 15.2	S.	40	·70	Cheyenne.
8.1	N W.	50	·42	Ft. Garry.	78	17.2	S.	42	·71	Cheyenne.
Apr. 13.1	N.W.	44	·30	Ft. Garry.	79	'74. Feb. 21.1	S.E.	24	·48	Santa Fé.
Sept. 16.2	N W.	50	·54	Ft. Sully.	80	Apr. 17.1	S.E.	12	[redacted]	Santa Fé.
Nov. 4.2	N.W.	44	·20	Bismark.	81	May 6.3	S.E.	30	·60	Salt Lk. C.
20.1	N W.	46	·64	Breckenr.	82	June 21.3	S.E.	16	·68	Ft. Sully.
22.1	N.W.	65	·21	Breckenr.	83	22.2	S.E.	14	·44	Ft. Sully.
28.2	N.W.	55			84	28.3	S.E.	12	·71	Santa Fé.
28.3	N.W.	58	·85	Atlantic C.	85	July 2.2	S.E.	10	·45	Ft. Sully.
Dec. 9.3	N.W.	[redacted]	·74	Father Pt.	86	13.2	S.E.	16	·60	Ft. Sully.
28.1	N.W.	60	·73	Alpena.	87	17.2	S.E.	10	·60	Ft. Sully.
'5. Jan. 2.3	N.W.	42	·86	Cheyenne.	88	21.3	S.E.	12	·60	Pembina.
'4. Feb. 13.1	W.	60	·33	Detroit.	89	Aug. 8.2	S.E.	12	·72	Pembina.
Oct. 28.1	W.	60	·34	Omaha.	90	19.3	S.E.	[redacted]	·87	Portl'd, O.
28.2	W.	55	·28	St. Paul.	[redacted]	20.2	S.E.	12	·60	Ft. Sully.
Nov. 4.3	W.	60	·31	Bismark.	92	24.3	S.E	28	·78	Salt Lk. C.
7.3	W.	66	·16	Duluth.	93	'74. May 30.2	E.	20	·86	San Franc
8.1	W.	70	·34	Duluth.	94	June 30.2	E.	12	·81	San Franc
8.3	W.	65	·68	Marquette	95	July 6.2	E.	16	·91	San Diego.
9.1	W	60	·61	Bismark.	96	19.2	E.	8		
13.1	W.	62	·77	Bismark.	97	19.3	E.	28		
21.1	W.	60	·38	Bismark.	98	20.2	E.	6		
23.1	W.	75	28·75	Alpena.	99	Aug. 17.1	E.	12	91	San Diego
24.1	W.	65	89	C. Rozier.	100	23.1	E.	8	·89	San Diego
27.3	W.	55			101	23.3	E	8	·87	San Diego
Dec. 22.2	W.	55	29·39	Bismark.	102	Oct. 1.2	E.	11	·84	Salt Lk. C
24.1	W.	60	·60	Alpena.	103	4.2	E.	7	·88	San Franc.
'5. Jan. 7.1	W.	62	·70	Cheyenne.	104	4.3	E.	12	·89	Portl'd, O.
9.2	W	[redacted]	·72	Quebec.	105	14.2	E	16	·97	San Franc.
19.3	W.	55	·68	Cheyenne.	106	'73 Nov. 18.1	N E.	43	·81	Galveston
'4. May 28.1	S W.	55	·59	Breckenr	107	18.3	N E.	36	·85	Montgom.
June 1.2	S.W.	77	·75	Ft. Sully.	108	Dec. 12.2	N E.	22	·67	Cairo.
10.1	S.W.	55	·68	Yankton.	109	24.3	N E.	24		
27.1	S.W.	52	·50	Yankton.	110	'74. Feb. 6.1	N E.	36	·93	Nashville.
Sept. 11.1	S.W.	55	·58	Ft Sully.	111	Apr. 18.1	N E.	24	·84	Galveston
Oct. 24.2	S.W.	52	·23	Bismark.	112	July 7.1	N.E.	24	·81	Omaha.
27.2	S.W	54	·76	Cheyenne.	113	7.3	N E.	22	78	Leavenw.
Nov. 6.1	S.W	[redacted]	·30	Bismark.	114	8.2	N E	22	·56	Omaha.
6.2	S.W.	60	28	Bismark.	115	27.3	N E.	28	·82	Ft. Gibson.
13.2	S.W.	[redacted]	·53	Ft Sully.	116	Sept. 8.2	N E	23	·84	Ft Gibson.
Dec. 24.2	S.W.	65	·58	Ft. Sully.	117	23.2	N.E.	24	84	Galveston
24.3	S.W.	50	·50	Ft Sully.	118	23.3	N E.	28	·85	Shrevep't.
'5. Jan. 7.2	S.W.	62	·59	Cheyenne.	119	24.1	N.E.	36	·85	Shrevep't.
10.2	S.W.	50	·76	Cheyenne.	120	24.2	N.E.	22	·80	Shrevep't.
15.1	S.W.	54	·60	Cheyenne.	121	24.3	N.E.	22	·87	Ft. Gibson.
16.3	S.W.	55	·86	Cheyenne.						

With an east wind of not less than seven miles per hour on Pike's Peak, the pressure on the Pacific coast was generally somewhat less than thirty inches, while on the east side of that station the pressure was a little greater than thirty inches, but at Santa Fé the pressure at these dates was not sensibly below the mean. The average velocity of the wind was only twelve miles per hour. The majority of these cases occurred in summer, and none occurred during the colder half of the year.

With a northeast wind of twenty-two miles per hour, a pressure less than thirty inches was generally found on the east side of Pike's Peak, its average direction being about southeast. Also a pressure greater than thirty inches was generally found on the north or northwest side of Pike's Peak, but in half of the cases the difference between these two pressures did not exceed a quarter of an inch.

Comparing the preceding results with those before found for Mt. Washington, we see that with a high wind from the north, northwest, west, or southwest, the position of the areas of low pressure is similar at both stations, but the centers of least pressure are frequently more remote from Pike's Peak, and are more widely scattered This difference may be partly explained by the small number of stations east and north of Mt. Washington. With a high south or southeast wind on Pike's Peak the position of the low center is sometimes apparently east of north. Similar anomalies are sometimes noticed on Mt. Washington, but they admit of a plausible explanation. We also notice that with a low center at a given locality, the high winds on Pike's Peak may have a great variety of directions. Thus when there is a low center at Fort Sully, we find high winds on Pike's Peak from north, northwest, southwest, south, and southeast. When there is a low at Bismark or Cheyenne we find high winds on Pike's Peak from northwest, west, southwest and south. This result may be in part ascribed to the small number of stations near the Rocky Mountains, which renders it difficult to assign the precise position of the center of least pressure. It also appears that the direction of the wind on Pike's Peak depends partly upon the position of the areas of high pressure, but this direction seems to be influenced by circumstances which cannot be clearly assigned from the want of observations at a sufficient number of stations.

With an east or northeast wind on Pike's Peak, there is generally no low center of much magnitude indicated at any of the stations, and the average difference between the high on one side and the low on the other is only one-third of an inch. Hence we conclude that while high winds on Pike's Peak from the directions north, northwest, west and southwest indicate a circulation about a low center according to the same law

is observed near the level of the sea, the winds from the uth, southeast, east and northeast give only obscure indica- ons of being governed by this law.

The winds observed on Pike's Peak from the east and south- ist are very few in number, particularly during the colder ortion of the year. The following table shows the total num- er of easterly winds for each month during a period of three ears from observations made three times a day.

	S.E.	E.	N.E.		S.E.	E.	N.E.		S.E.	E.	N.E.
'an.	2	0	4	May	6	6	19	Sept.	5	4	36
'eb.	1	0	3	June	6	2	12	Oct.	2	9	19
lar.	1	0	13	July	9	12	49	Nov.	1	0	10
pr.	4	0	15	Aug.	7	8	25	Dec.	2	2	19

Thus we see that during the six months from November to .pril, an east wind was observed only twice in a period of ıree years. In one of these cases the velocity of the wind was x miles per hour, and in the other case three miles. The inds from east and southeast constitute less than three per cent all the winds, whereas in the same latitude near the level the sea the winds from these directions constitute twenty er cent of the whole number. We also notice that on Pike's eak easterly winds are four times as frequent in summer as winter, which seems to indicate that these winds are depen- ent upon difference of temperature more than upon difference pressure. On the elevated plateau west of Pike's Peak are ctensive regions where the temperature is as high as it is on ıe east side at a much lower level; whence it may result that the height of Pike's Peak the temperature of the air on the est side is sometimes sensibly greater than it is on the east de.

The only station of the Signal Service whose direction is early south from Pike's Peak is Santa Fé. I have examined ıese observations to see what was the direction of the wind on ike's Peak at the time of low barometer at Santa Fé. The llowing table shows all the cases in which there was a consid- able depression at Santa Fé during the period of the pub- shed observations at Pike's Peak. Column second shows the ıte of the minimum; column third shows the lowest observa- on of the barometer; column fourth shows the direction and rce of the wind at Santa Fé; column fifth shows the direction ıd force of the wind on Pike's Peak at the date named in lumn second; column sixth shows the wind on Pike's Peak the time of the last preceding observation; and column venth shows the position of the center of the nearest low area s shown by the observations.

Low barometer at Santa Fé.

No.	Date.	Santa Fe. Bar.	Santa Fe. Wind.	Wind on Pike's Peak. At date.	Wind on Pike's Peak. Prev. ob.	Low.
1	'73. Nov 22.2	29·51	Calm.	N E 20	Calm.	Ft. Gibson.
2	Dec. 2.2	·31	S.W. 26	S.W. 16	S.W. 20	Leavenworth.
3	7.2	·51	S.E. 8	S.W. 32	S.W. 16	Corinne.
4	'74. Jan. 3.2	·59	S.W. 6	S.W. 20	W. 40	Ft. Sully.
5	21.2	38	S.W. 12	W. 10	W. 16	Cheyenne.
6	Feb. 12.2	·18	W. 24	W. 25	W 16	Dubuque.
7	18.3	·39	S. 8	W. 8	S.W. 20	Ft. Sully.
8	21.2	·28	S.E. 12	S.W. 20	S.E 24	Santa Fé.
9	24.1	·43	E. 12	S.W 18	S.W. 16	Santa Fé.
10	Mar. 6.2	·26	S.W. 22	S.W. 12	S.W. 12	Cheyenne.
11	16.2	·18	S.W. 20	S.W. 16	W. 24	Ft Sully.
12	30.1	·46	S. 16	S. 14	S.W. 20	Salt Lake City
13	April 6.2	·42	S.W. 30	S. 6	W. 15	Salt Lake City
14	12.2	·42	N.W. 20	N 26	S. 32	Ft. Sully.
15	May 1.3	·41	W. 20	W. 24	S.W. 20	Leavenworth.
16	9.1	·44	S.W. 12	S.W. 20	S.W. 36	Ft. Sully.
17	Oct. 24.2	·59	S.W. 8	S.W 52	S. 36	Bismark.
18	Nov. 3.2	·57	S.W. 6	S.W. 30	S.W. 40	Bismark.
19	21.3	·33	S.E. 12	S.W. 28	S.W. 32	Bismark.
20	26.2	·48	S.W. 4	W. 22	W. 20	Duluth.
21	Dec. 15.2	·56	S.W. 12	N.W. 26	W. 12	Ft. Sully.
22	21.1	·50	S. 8	N E. 4	N.W. 10	Santa Fé.
23	27.1	·41	S.E 4	S. 15	S.W. 20	Colorado Spr.
24	'75. Jan. 5.2	·42	Calm.	S.W. 15	S.W. 22	Cheyenne.
25	12.1	·36	S 4	S.W. 1	S.W. 10	Salt Lake City
26	26.1	·41	N E. 4	Calm.	W. 15	Corsicana.

We see that the center of low pressure generally passes north of Pike's Peak, and there are only six cases in which the low was south of Pike's Peak, viz: Nos. 1, 8, 9, 22, 23 and 26. In the case of Nos. 1 and 22 the wind on Pike's Peak was northeast; in No. 23 it was from the south; in No. 26 it was calm; in No. 8 it was southeast at the time of the last preceding observation; in No. 9 it was southwest and had been blowing from some western quarter for a period of forty-eight hours. The first five cases accord tolerably well with the results found for the winds on Mt. Washington, but No. 9 seems to indicate that the system of circulating winds which prevailed at that date at lower stations did not extend as high as Pike's Peak. We see that one reason why easterly winds are so rare on Pike's Peak, particularly during the winter months, is that the low centers generally pass north of that mountain.

The preceding investigation seems to warrant the following conclusions, which are an extension of those stated on page 19.

1. At the height of 6,000 feet the winds circulate about centers of low pressure as they do near the level of the sea, but frequently the position of the center of low pressure is sensibly different at the height of Mt. Washington from what it is at

lower stations, and we sometimes find low areas resulting from a circulation of the surface winds which does not extend to the height of 6,000 feet.

2. At the height of 14,000 feet the fluctuations of the barometer are quite large, but the centers of low pressure at this elevation differ in position from those at lower stations, so that frequently there appears to be but little correspondence between the movements of the wind on Pike's Peak and the fluctuations of pressure at the lower stations, and we frequently find areas of low pressure resulting from a circulation of the surface winds which does not extend to the height of 14,000 feet.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College of the class of 1871.

Art. II.—*Notes on the Mesozoic Strata of Virginia*; by Wm. M. Fontaine.

In this paper I present a summary of the results attained by a series of examinations, made in the Mesozoic strata of Virginia. These examinations have occupied the larger portion of my summer vacations for several years. Some of my conclusions were reached sometime ago, but as the field presents many difficulties in its study, and as I arrived at some unexpected results, I was not willing to present them until I had made repeated observations, and at remote points. As I have been very slow myself to reach some of these conclusions, I must expect that others will require convincing evidence before accepting them. Such evidence perhaps cannot be presented in the limits of an article. To deal fully with my material, whether stratigraphical, lithological, or derived from the fossil plants, will require an extended memoir. I hope soon to present this.

The great denudation which the Mesozoic beds and the enclosing crystalline or Azoic rocks have undergone, the proneness of the former to fall into a loose incoherent mass, the covering of drift matter and clay which often conceals the outcrops, all unite to render the task of studying the Mesozoic of Virginia a very laborious and difficult one.

It is due to Professor Wm. B. Rogers to state that his careful and accurate observations, made in the early surveys of Virginia, have rendered my work very much easier than it would otherwise have been; much that I have observed is merely a confirmation of what he had already noted. He has given correctly the location, boundaries and general character

of the several Mesozoic areas, but as the relations of some of these do not seem to be understood, it will be necessary for me to give here some of these features with explanations. It will be understood, as was shown by Professor Rogers, that in Virginia the Cretaceous, if it exists, does not appear to view, hence the term Mesozoic includes only strata older than Cretaceous. In Virginia the Jurassic forms the youngest Mesozoic, and is overlaid by the Tertiary.

The several Mesozoic Belts.—The largest and most important Mesozoic belt is that which enters the State from Maryland, west of Washington, being the continuation of the tract so largely developed in New Jersey. For the sake of distinction it may be called the *New Jersey Belt.* It has all the features seen in its exposures farther north, and I have no reason to doubt its being of Triassic age. So far as can be ascertained from the scanty attainable evidence, it is in part, the oldest of the Virginia Mesozoic. It extends unbroken to the Rapidan River in Orange County, and has to the south, a few miles distant, a small outlier now separated from it owing to erosion.

A second narrow belt, a mere remnant which has escaped erosion, is found on James River, in the northern part of Buckingham County. This is now widely separated from the preceding belt, but possibly, though not probably, it once formed a part of it. This may be called the *Buckingham Belt.* A third narrow belt extends from the North Carolina border, near the Dan River, in a northeast direction through Pittsylvania into Campbell County. It has a width of four to eight miles, and a length of about thirty miles. Though now separated by a narrow interval from the Dan River Coal Field in North Carolina, it no doubt was once connected with it. This may be called the *Pittsylvania Belt.*

A fourth narrow belt extends northeast from Prince Edward into Cumberland County. It contains in its southern extremity a coal bed which is worked locally, and is the only belt except the Richmond Coal Field which contains any coal. This may be called the *Prince Edward Belt.* All of these four belts have many features in common. They have all suffered greatly from erosion. They have a northwest dip of varying steepness which extends unreversed across each belt. It is quite possible that the last two were once connected, but if so, it would seem to have been by narrow arms or inlets. Except in very rare cases these belts, and the enclosing Azoic rocks, have all been planed down to a uniform level. These four belts may be grouped as interior belts.

Passing to the east we find a fifth belt, nearly enclosed by Azoic rocks, but at its northern end touching later formations. This, which we may call the *Richmond Belt*, begins a

ɔrt distance south of the Appomatox River in Amelia ·unty, and extends in a direction a little east of north to the :inity of Chesterfield Station, in Caroline County, on the chmond, Fredericksburg and Potomac Railroad, where it is erlapped by later formations. On the Chickahominy River, rthwest of Richmond, this belt is broken by an interval of zoic rocks three miles wide, which separates the northern from e southern portions. The southern portion alone yields coal, d as it differs somewhat from the northern portion, we may re it the distinctive name of the Richmond Coal Field, while e northern portion lying mainly in Hanover County, may be lled the Hanover area. No doubt the two were once concted by at least their latest formed beds. Both sections of e belt have suffered much from erosion, and we find here ain the striking feature of the planing down of the yielding ›ds of the Mesozoic, to the same level with the most resistant zoic strata. The coal field is separated from the Tertiary on e east by a belt of granite and gneissoid granite about twelve iles wide. This belt seems always to have formed the eastern ›rder, cutting off the southern end of the coal field from communication with the open sea. It is by the sinking down of is granitic border to the north, that the Tertiary beds are ıabled in that quarter to overlap the Mesozoic of the Hanover ea. The northern end of the coal field proper sends fingerze projections into the Azoic, which are the deepest portions troughs which have escaped erosion. Some of these are ıtirely isolated from the main field. They sometimes furnish :ry instructive sections, throwing light upon the geological story of the coal field.

Still farther east, and differing in position from all the pre-ding belts, we find two others geographically distinct, but ›ologically the same. These lie east of, and outside of the zoic rocks, and are really a shore formation, which must have ctended to the open sea, though the indications are that the ›mmunication was very imperfect. Owing to their apparent istinctness we must consider them separately.

The sixth belt, or the first of these border belts, begins at 'etersburg and extends along the eastern edge of the Azoic ›cks, in a direction almost due north, past Richmond to near ıe termination of the Hanover area, which it overlaps on its astern side. In this quarter, the uppermost beds of the lanover area appear to pass into the lowest of the belt in queson, and both are overlaid by the Tertiary. It is quite possible ıat this belt, if it could be traced farther east, under the Terary, would be found to extend unbroken farther south. At ıy rate, Professor Rogers states that a small patch of strata of ıe same character is exposed in the bed of the Nottaway River

in Sussex County, twenty miles south of Petersburg. In this direction the Tertiary strata overlap the Azoic, and bury the subjacent formations too deeply for the erosion of the streams to expose them, except in the locality mentioned. Professor Rogers, in his earlier reports, stated that an area of Mesozoic exists near Hick's Ford, but in his later reports, he states that the above-mentioned locality is the farthest point to the south at which the Mesozoic is found. I have not visited this place. South of the Nottaway, no traces of the Mesozoic have been seen. This belt may be called the *Petersburg Belt.* A seventh belt similar to the last is found nearly in the prolongation of it in a direction due north. This begins a little south of Fredericksburg and continues along the eastern border of the Azoic, in a northerly direction. Its western margin passes several miles west of Alexandria. As it passes out of the State it bends to the northeast, so as still to hug the eastern margin of the Azoic. So far as I have traced it, it extends at least as far north as Baltimore. This may be called the *Fredericksburg Belt.* Both the last mentioned belts always are found on the east of the Azoic, and are never seen invading it. In Virginia they dip eastward under the Eocene, and in Maryland under the Cretaceous. The dip is usually to some point in the southeast, and is very gentle. It is quite probable that these two belts are connected farther east, under the Tertiary, but along the margin of the Azoic they are separated by a considerable interval of the Tertiary, where this latter overlaps the Azoic. Geologically they form one area, which is very distinct from the Richmond belt. It is the relation of this border formation with the Richmond belt which is usually misunderstood. As we shall see, when we consider the character of the strata contained in them they differ greatly, and simply touch in Hanover County, where the different directions of the several areas cause them to meet at an acute angle. The statement made in the revised edition of Dana's Manual gives the usually accepted opinion. This statement is that the Richmond area begins on the Potomac, and extends south to the Appomatox River. I shall speak of these two belts as the border belts, and they are distinguished as the Petersburg and Fredericksburg belts as above stated. My studies of the Mesozoic in Virginia have been confined almost entirely to the border belts, and to portions of the Richmond belt, as these offered the most promising field.

The existence of all these belts, except the border ones, is due, I think, to the gradual depression of certain elongated tracts in the Azoic which have approximately the direction of the strike of the Azoic strata. The location of these depressed areas is fixed by the previous establishment of lines of weakness, by the processes producing the metamorphism of the

Azoic. The force producing the sinking along these lines was plainly a lateral thrust, which at least in the case of the Richmond belt, acted from east to west. The sinking seems to have commenced at or near the close of the Permian period, and to have continued till toward the close of the Jurassic. The depression was accompanied by, in many cases, extremely rapid sedimentation, and toward its end, produced a rupturing of the crust and an outpour of fused rock.

Wherever I have had an opportunity to examine carefully the Azoic rocks bordering the Mesozoic belts, I find them penetrated by dykes of true igneous matter, such as felsite, granite, diabase, etc., which are much older than the Mesozoic beds. These dykes run parallel with the Mesozoic belts, and are confined to their vicinity. Their presence indicates that in the general metamorphism of the country, fracturing of the crust took place, and the metamorphic action was excessive along certain lines. There is no doubt in my mind that this previous weakening of the crust in definite belts, has much to do with the subsequent emission of the Mesozoic trap rocks in such well defined areas as we find to exist. I find also here a good example of the application of Von Richthoven's conclusions concerning the order of precedence, and the association of igneous rocks.

Topography.—The topography of the Azoic, and the included Mesozoic areas, is very significant, and may be studied to great advantage in Virginia. What I shall say under this head is more particularly applicable to the district which is limited on the north by the Potomac, on the south by the Appomatox, on the east by the Tertiary, and on the west by the Catoctin range of mountains. I apply this, the Maryland name, to that more or less connected range which penetrates far into Virginia, under many different local appellations. It runs about fifteen miles east of, and nearly parallel to, the Blue Ridge.

The first thing that strikes the observer in this district is the very gently undulating character of the surface, which is so marked as to arrest the attention of the non-scientific, and to induce speculation as to the causes producing it. The country from the Catoctin eastward to the Tertiary, is a gently undulating plain, descending from about 500 feet in elevation to the level of tide. Unlike the country near the Blue Ridge, and farther west, the topography is almost uninfluenced by the structure and composition of the underlying rocks. In the area in question we have strata showing all gradations of hardness, with all degrees of proneness to decomposition, and dipping at various angles, often steeply, yet all are planed down to a uniform level. The streams, except the smallest creeks, cross the strike of the strata nearly at right angles, and are hardly at all

guided or controlled in their courses by variations in the rocks across which they flow. They seem to be steadily deepening their channels, which work they have continued to perform, as it would seem, without noteworthy pause since their courses were first marked out.

The absence of any considerable inequality on the surface is well shown along the line of the Chesapeake and Ohio railroad, which runs between Richmond and Gordonsville, for fifty miles, directly across the strike of the various strata. In the area now in question the grades of the road are gentle, yet it turns aside for no hill, and has only one or two cuts which reach the depth of fifteen feet. Between the rivers, the country roads running east and west, pass over an almost uniformly level surface, of greater or less width, according to the distance apart of the principal streams. They are often almost devoid of water, as the smaller creeks rise in these levels, and flow north and south into the principal streams. There are many evidences showing that the level areas between the main streams are remnants of the original plane to which the country was cut down, and that the topography is entirely due to the action of the present system of streams in cutting down from this initial plane. Thus we find in the hill tops, and over the broader levels, certain clays and cobbles which occupy the same horizon always, and serve to fix the plane of this old surface. While peculiarities of erosion are shown in the character of some of the strata of the older Mesozoic belts, yet the principal denudation, and the most abnormal action, appear in the formation, and at the close of the deposit of the latest formed beds.

The condition of the surface of the Azoic rocks is also instructive. Those which admit of the formation and retention of smoothed and rounded forms, usually present such appearances. This is notably true of the granites and gneisses in the vicinity of Richmond.

The depth to which decay has penetrated here is far less than in the southern and southwestern parts of the State. In the latter we find strata not specially prone to decay, often decomposed, and changed to a loose earth, for fifty and even one hundred feet. This loose matter is suggestive of the way in which some of the later formed Mesozoic beds may have obtained their material, and its peculiar arrangement. This will be noticed later.

In the area of the Azoic with which we are now concerned however, the case is different. We rarely find the rocks decayed to as much as twenty feet in depth. Very often the surface clays rest on sound rock, or on that which is decomposed but a few feet below the surface. Again this decay has in nearly all cases taken place since the erosion above mentioned. We often

find, resting on such decayed surfaces, large stones and gravel deposited at this period of general erosion, which shows that the decay could not have existed when these stones were deposited. All the facts point to the conclusion that in this northern Azoic belt, the agent which produced such extensive general denudation found, it is true, the Azoic deeply decomposed, and having its surface in the condition now found in the southern and southwestern part of the State, but it swept off all this loose granitic matter, and even reached the sound rock in many places. We may now turn to the consideration of some of the special features shown in the different belts.

The New Jersey Belt.—Of this I shall have little to say, except to call attention to certain remarkable deposits of stones on its western margin. The deposits of similar matter in the northern exposures of this belt are called conglomerates, and sometimes breccias. For the beds in Virginia these terms are inadequate. They are rather beds of bowlders. The northwest dip of the Mesozoic beds with which they are associated, and their position on the western side of the belt, show that if these deposits are contemporaneous with the other Mesozoic strata, they are the last formed. But in some cases at least it is not clear that the period of their deposition followed immediately that of the typical Mesozoic beds. These stones are found in unconnected deposits on the western edge of all the interior belts. In all these locations we find essentially the same features, the close agreement of which indicates that they are of the same or nearly the same age. In character these beds of stone differ much from the normal Mesozoic strata with which they are associated. These latter consist of sandstones and shales, well sorted and bedded by water action, and with their mineral constituents too much decomposed to betray, except in rare cases, the parent rocks. The case is different with the stones in question. They are of such large size, and the material is so fresh, that there is no difficulty in determining the precise character of the rock from which they were derived. Indeed the material is often as sound as if it had been taken from a quarry freshly opened. The material in nearly every case comes from rock found in place at a greater or less distance to the west. This distance is often many miles. The stones are usually imperfectly rounded, or subangular. They are packed in a fine, more or less argillaceous matrix, derived either from the erosion of the normal Mesozoic beds with which they are associated, or from comminution of their own substance. These deposits are often sharply distinct from the associated normal Mesozoic beds, and appear as if deposited in depressions in them excavated by erosion. But again they appear sometimes alternating with shales, and thus to form strata contemporaneous with the nor-

mal ones. The most common matrix enclosing the stones is red shale.

The most important, and by far the longest uninterrupted bed of stones, is that known under the name of the "Potomac Marble," or the "Limestone Breccia." This enters the State near Point of Rocks, Maryland. At Point of Rocks it is well exposed by the cuttings for the Metropolitan Branch of the Baltimore and Ohio Railroad. I examined the deposit at this place carefully to determine the character and origin of the stones. The stones here are all limestone. After long and careful search I found only one fragment not limestone. This was a slab about eighteen inches wide and four inches thick, of apparently Potsdam sandstone. In this vicinity the Azoic rocks are mica slates. Azoic limestone occurs some distance to the northeast, and may have furnished an impure pinkish limestone, which ranks third in the abundance and size of the fragments it has afforded. These are rarely over six inches in diameter and usually are under this size. The most abundant stones come from the dark bluish limestones of the Lower Silurian, which are not found south of Pennsylvania. This limestone gives fragments sometimes two feet, and often twelve or eighteen inches in diameter. A white marble which is highly siliceous, and shows on weathered surfaces a sandy character, is the second in abundance and in the size of the fragments, which are sometimes a foot in diameter. These stones are when large, subangular, when small, partially rounded. They are cemented by a fine grained red shale, apparently eroded from the adjoining normal Mesozoic red beds. This is rendered highly calcareous by an intimate mixture of it with finely comminuted limestone. The stones are firmly cemented by this, and the whole lies in massive ledges having apparently a northwest dip. This may however be only a false bedding. This formation, here about half a mile wide, extends far into Virginia, with a predominance of limestone fragments. Professor Rogers has shown that it extends unbroken as far as Warrenton, with a constantly diminishing amount of limestone. As this limestone must have come from Maryland and Pennsylvania, we see that some of the stones must have traveled long distances, viz: forty or fifty miles. The predominance of limestone is marked for some distance south of Leesburg.

A second deposit, not connected with the last, is well shown near Culpepper Court House, where I made a careful examination of it. This does not show any stratification, or limestone fragments, but consists of a mass of partly rounded and subangular stones, usually perfectly sound, and all packed in a fine-grained red shale, which binds the whole into an exceedingly [illegible] and durable rock. The stones are composed of the char-

acteristic rocks of the Blue Ridge, some twenty or twenty-five miles to the west, and northwest. They are commonly composed of a tough epidotic schist, subangular blocks of which, two feet by eighteen inches, and two feet by two and one-half, sometimes occur. The most abundant material is a compact chloritic schist which yields subangular stones two feet in diameter. By far the most common size, however, of all the stones, is from six to eight inches. Rocks yielding this material may be found nearer than the Blue Ridge, though none were seen in the immediate vicinity. Similar deposits are found at various other points on the west side of this, and the other interior belts. I will mention only one more, for the sake of illustration, and this occurs in the—

Pittsylvania Belt.—This deposit is remarkable for the great size and soundness of the stones, and for the complete contrast that it presents with the normal Mesozoic strata with which it is associated. These latter are here fine-grained red shales, dipping pretty steeply northwest. On the western edge of these, and apparently lying in a trough excavated by erosion in them, we find on George's Creek the bed in question. This was mentioned by Professor Rogers, on account of the large size of the stones. I made a careful examination of it. The most abundant and largest stones are composed of a coarse grained gneiss, which occurs in masses, sometimes hardly at all abraded, and up to four and five feet in diameter. Very commonly they are two and three feet in diameter. A fine-grained granite yields masses three and four feet in diameter, which show more abrasion. These occur with other material, all enclosed in a matrix composed of red shale, eroded from the normal Mesozoic, mingled with comminuted material similar to the large stones. All the large stones are remarkably fresh, and the whole mass is totally unlike anything seen elsewhere in this belt. The parent rocks yielding the stones may exist in the vicinity, though none exactly similar were seen in place. The normal strata of this belt may be divided into two series. The lower one contains predominant red and variegated shales, and red or brown sandstones. The sandstones often contain numerous, more or less angular, particles up to an inch or two in diameter, of the adjoining Azoic rocks, and commonly give evidence of rapid erosion and deposition. There is one very remarkable sandstone near the top of this series, which is composed almost entirely of feldspar. It consists of numerous partly rounded and slightly decayed particles of feldspar, with many perfectly fresh fragments of the same, showing brilliant cleavage faces. These are cemented by a felsitic paste into a firm rock, which can only by close inspection be distinguished from granite. It is difficult to see how

such a rock could have been formed out of any of the Azoic rocks in the vicinity, for these contain a good deal of quartz, even when richest in feldspar, and this sandstone contains very little.

The upper series contains a predominance of reddish and dark bituminous shales and gray grits. Only faint traces of coal exist, in the form of thin films. No plant impressions were seen but some silicified wood occurs. The dip is northwest over the whole belt, varying from thirty to forty degrees. This constant high dip indicates a thickness for the formation which is not justified by the other indications. In the description of the Richmond coal field I will state what I think is the explanation of this apparent anomaly.

Deposits of bowlders similar to those above described appear, according to the statements of Emmons and Kerr, to be found associated with the Mesozoic of North Carolina. Emmons mentions beds of large stones as found on the west side of the Dan River coal field. There the normal strata dip northwest. Kerr mentions similar beds as occurring on the east side of the Deep River coal field, where the normal strata dip southeast. He however thinks that these stones come from the Azoic on the east, and attributes their transport to a pre-Triassic glaciation. I do not understand on what grounds Professor Kerr thinks that these beds are pre-Triassic, as he does not indicate any change of dip in the associated normal beds. This southeast dip and the position of the beds, would indicate that they are, as in Virginia, post-Triassic. Professor Emmons mentions that the Egypt shaft after passing through twenty-eight feet of soil (?) penetrated two feet of large stones, resting on the coal shales. This may be the same deposit with that of Professor Kerr. It does not seem possible that water action alone could have deposited these stones in their present position. For if we could conceive of a torrent of such power as to be able to transport these masses, and which would at the same time not remove the fine matrix in which they are imbedded, we should still be unable to understand how water could reach and remove material which had never been exposed, as surface rock, to the decomposing action of atmospheric agencies.

I will pass over the Buckingham Belt and the Prince Edward Belt, as I had no opportunity to study them, and will consider next the—

Richmond Coal Field.—This portion of the Richmond Belt, which, as previously defined, lies south of the Chickahominy River, is the only Mesozoic area in Virginia which shows the structure of a basin. The strata may be divided into two series, which show, as a whole, very marked differences, but between which no distinct line of separation can be traced.

ıe lower series, from three hundred to five hundred feet c, rests immediately on the granitoid gneiss, which forms loor of the basin. It contains all the coal found in the . The number of coal beds is variable, but the most ›rtant are usually two or three in number, all contained in the space of about one hundred feet, and the lowest g near the floor. In placing this coal-bearing portion next ıe granite, I follow Rogers and Lyell, as their observations, :h were more extensive than my own, show that the inter- between the lowest coal beds and the granite is quite ıble. The associated strata are usually flaggy sand- es, and more or less indurated shales, the material of all g so thoroughly sorted by water action and so completely ıged that the parent rock cannot be recognized. The beds proof of a good deal of disturbance in the presence of ːkensides," contortion, crushing and induration. Faults :t both this and the upper series, and suddenly collapsed ːlinals of small width occur, so that the dip is quite variable. a rule the dip on the eastern side is westward and on the ˏern side eastward, being steeper on the latter side, and the ;a sometimes attain here a perpendicular position.

he upper series is perhaps not more than fifteen hundred feet k, and differs in many points from the lower. The strata are ıly sandstones, sometimes coarse and conglomeratic, and as ers has shown, possessing the peculiar composition of a ture of feldspar, quartz and mica, unsorted, and but little ›mposed. They form a sort of granitic grit, which causes the : to resemble granite. Subordinate beds of shale exist. ; series shows less disturbance than the lower. The dip is e gentle, the beds are but little consolidated, or affected by hing and rubbing. It contains no coal, and none except :ed, poorly preserved plants. The entire upper series shows ks of having been deposited in a rapidly sinking area, into :h was poured an abundance of coarse matter, obtained by rapid erosion of the surrounding granitoid rocks.

; is clear that much of the disturbance shown by the lower s occurred during this sinking, which has also affected them ı steeper dips than are found in the upper series. The er beds were evidently deposited slowly, on a pretty stable ı, which remained at the same level long enough for the ›ortant coal beds now found to be formed. The subsequent cing seems to have been too rapid to permit the growth of icient vegetation to produce coal. Both series are pene- ˏed by dykes of igneous rock. The rolls in the strata and faults affect the structure of the field to such an extent t it is difficult to determine its depth, and determinations n shafts and borings cannot be relied upon absolutely. To

illustrate this, I may mention two cases. Lyell states that the Midlothian (old) shaft was sunk within the field to the west of the previous workings, and entered the coal three hundred feet higher than was expected from the dip, thus giving an upthrow of this amount. This is on the east side of the field. On the west side at the Dover Mines, the company owning the works attempted to develop a new portion of the field by sinking a shaft a few hundred yards to the east of their old workings. They penetrated the entire series of strata, and found nothing workable.

My examination of some of the finger-like remnants of the Mesozoic, now found at the northern end of this field, thrust out in the Azoic, put me in possession of what I think is the explanation of the peculiarities of the structure of this field, and of the interior belts. The history of these areas, briefly stated, seems to be as follows:—

The strata were laid down in depressions, which, originally shallow, were subsequently deepened by a more or less rapid subsidence. The subsidence was due, as previously stated, to the operation of a lateral thrust. It continued until faults and overturned anticlinals were produced. In the interior belts these operated to produce a constant northwest dip. This resulted from the fact that the western sides of the severed earth prisms dropped, producing sometimes by a roll of the prisms an upthrow of the eastern side. This appears to occur in some of the faults of the Richmond coal field also. When the strain did not result in producing rupture and faulting, it caused the development of an anticlinal, affecting but a narrow belt, which was overturned to the eastward, thus producing also a continuous northwest dip. Where the strata have suffered enormously from erosion, and where almost precisely similar beds are formed by the similar conditions of deposition found repeated at different horizons, as is often the case in the interior belts, it is almost impossible to detect reduplications by faulting and folding. When the period of faulting was reached, eruptions of trap took place. It will thus be seen that the continuous dips would by no means give a true indication of the thickness of the series.

In the Richmond coal field the faults and narrow overturned folds are not of sufficient magnitude to produce, as in the interior belts, continuous dips, but suffice only to render very variable and uncertain the dip and position of the strata toward the center of the field. The general result seems to have been to flatten the dip here, and to steepen it on the western side. Some of the twists in the strata, produced by the overturned anticlinals, are of extremely limited extent. I have seen them only a few feet wide.

The direction, in which the lateral thrust operated in this field, was from east to west, and it seems not yet to be exhausted, for this region is often affected by minor earthquakes, and at intervals of ten or fifteen years, by very powerful ones, the last occurring a few years ago. The shocks pass from east to west. It is probable that the gradual depression of the coast is connected with this westward thrust.

Fossil Plants.—So far as known to me, the only plants from this field which have been published and described, are those made known by Rogers and Bunbury. Both of these authors considered the plants to be of the age of the lower Oolite of England. Most geologists, however, seem to agree in considering the beds yielding the plants, to be of the age of the Keuper, or Upper Trias. It must be borne in mind that only the lower, or coal-bearing portion, has yielded these plants.

Among European authors, Heer and Schimper are the only ones who, so far as I know, express an opinion concerning the age of the beds, based on an examination of the plants. I have not seen Heer's remarks, and hence do not know on what grounds he concludes that the plants are Triassic. Schimper, on page 277, vol. i, of his Pal. Veg., founds his belief in the Triassic age of the beds yielding the plants, both on the animal and plant life. I will consider only the latter.

He says, in speaking of the characteristic Equisetum of this field, which he calls *Equisetum Rogersii*, that it is nearer to *E. arenaceum*, the characteristic Equisetum of the Trias, than to *E. columnare*, the plant of the Lower Oolite with which Rogers and Bunbury thought it to be identical. He, however, only saw a cast of the interior of the Richmond plant. He says, farther, that this coal field has Pterophylla and Ferns, which have most affinity with the characteristic species of the Keuper. It does not appear from what source he derived this impression.

He is mistaken both concerning the Equisetum, and the other plants from this field. This Equisetum is next to *Macrotæniopteris grandifolia*, the most abundant and widely diffused plant of the field. I have beautifully preserved specimens, on a fine-grained shale, which shows with the utmost nicety the minutest details of the exterior of the plant. It is certainly so close to *Equisetum columnare* that, if separated, it can only be made, at most, a variety. The most abundant, widely diffused and characteristic plant, is *Macrotæniopteris grandifolia*, described by Rogers as *Tæniopteris grandifolia.* It is a curious illustration of the confusion existing in the minds of European writers concerning this coal field, to find that Schimper, in speaking of this plant, refers it to the *Oolitic* beds of the Richmond coal field, while he refers its constant companion, the Equiestum above mentioned, to the Keuper of the Richmond field. The

fact is, that when both of these plants occur at a locality, they are so closely associated that they are confined to the same layer, from which they seem to exclude nearly all other species. Schimper also refers to the Oolite of the Richmond coal field, another plant often found associated with these two, viz: *Neuropteris linnæifolia* Bunb.

The *Macrotæniopteris* is allied more closely to the Oolitic *Macrotæniopterids* of England and India, than to any older plants. The nearest to it, among older plants, is the *Tæniopteris gigantea* Schenk, of the Rhætic. Nothing like it exists in the Trias. The *Pterophylla* of the Richmond beds belong to the Rhætic type, illustrated by *Pterophyllum Braunianum*, which type Schimper separates under the name of *Ctenophyllum*. These plants are very different from the Keuper type of true *Pterophylla*, as shown in *P. Jägeri* and *P. longifolium*. The plant which stands third in distribution and abundance, is one which I cannot distinguish from *Pterophyllum Braunianum*, which is a characteristic Rhætic plant, as given by Schenk.

The Ferns are either similar to Rhætic forms, or have an affinity with still later ones. I have fine specimens of a splendid Fern, which is allied to *Cyclopteris pachyrachis* Gœpp., though it is a smaller plant, and is a new species. From its association with *Neuropteris linnæifolia* Bunb., and the resemblance of the two, I think that it is the male form of Bunbury's plant. They are both allied to *Acrostichites Gœppertianus* Schenk, which is a Rhætic plant. I have also specimens of a fine Fern, closely allied to, if not identical with, *Asplenites Rösserti* Schenk, which is a characteristic plant of the Rhætic. Others might be mentioned, which show either Rhætic or Liassic, and even Oolitic affinities. I have not seen in this field a single Triassic plant.

In the revised edition of Dana's Manual, *Pecopteris* (*Lepidopteris*) *Stuttgartensis* Brongt., is given as occurring in this field. This statement is probably based on the identification by Heer, of this plant with Bunbury's *Pecopteris bullata*. I have seen nothing like *Pecopteris Stuttgartensis* in this field, but I have a number of fine specimens of a large Fern, which I take to be Bunbury's *P. bullata*. If they are not, then I have not seen his plant, though I have collected from the localities yielding it. My specimens show more of the character of the plant than Bunbury's which, as is known, were very imperfect. It is [illegible] not *Pecopteris Stuttgartensis*. I have devoted more [illegible] to these Richmond plants than I would otherwise have [illegible] this flora is the oldest* of the Mesozoic of Virginia and serves as a point of comparison for the plants found

[illegible] mean that the beds containing this flora are the oldest of [illegible] Virginia. The lowest strata of the interior belts have [illegible] and are all, I think, Triassic. This is the oldest flora yet

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in the other belts. These plants all come from the lower series. As the result of my preliminary study of them, I conclude that the lower series is certainly not older than Rhætic, and if it be not Rhætic, then it is younger. Some may question the separation of the Rhætic from the Triassic. Whatever may be the evidence of the animal life of these two formations, the plants are different, and the Rhætic flora is rather to be reckoned with the Liassic than the Triassic flora. Schimper, Heer and Schenk, all show that the Rhætic flora contains no Triassic species.

[To be continued.]

ART. III.—*Discoveries of the United States Fish Commission: Notices of fifty species of east-coast Fishes, many of which are new to the fauna*; by G. BROWN GOODE and TARLETON H. BEAN.

THE object of the present paper is to give a brief summary of the coast investigations of the United States Fish Commission (Professor S. F. Baird, Commissioner) since the publication of a similar paper in this Journal for December, 1877, pp. 470–478. Certain species which should be mentioned here have not yet been identified; these will be reserved for a future paper. Full descriptions of species and discussions of questions hinted at in these notices have appeared or will appear in the Proceedings of the United States National Museum.

1. *Chilomycterus fuliginosus* (DeKay) Gill.

This species had been dropped by common consent from the faunal list; but after careful study of a specimen seined on Watch Hill beach, Rhode Island, September 12, 1874, we feel compelled to restore it.

2. *Hippocampus antiquorum* Leach.

Taken with a school of mackerel on George's Bank, August, 1873.—An addition to the fauna of the Western Atlantic.

3. *Glyptocephalus cynoglossus* (Linné) Gill.

The craig flounder abounds in deep water off the coast from Cape Ann to Halifax, occurring at a depth of thirty-five fathoms in Ipswich Bay, Massachusetts, and in Bedford Basin, Halifax Harbor, and seaward to a depth of 111 fathoms. Careful study of a large series of specimens has enabled us to unite with this species *Glyptocephalus acadianus* Gill and *Pleuronectes elongatus* Yarrell.

4. *Hippoglossoides limandoides* (Bloch) Günther.

Hippoglossoides dentatus (Storer) Günther, is apparently identical with this European species. The genus *Pomatopsetta* Gill,

which was founded on Storer's *Pleuronectes dentatu* characters by which it may be distinguished from *i soides*, and it should be set aside. *Hippoglossoides li* is a deep water species found constantly with the prec

5. *Pleuronectes glaber* (Storer) Gill.

As a rule, the female may be distinguished from by its smooth scales, especially in the breeding seaso its greater size. Gravid females were received fron Massachusetts, January 10, 1878. The eggs are one of an inch in diameter. (Bean.)

6. *Ancylopsetta quadrocellata* Gill.

Of this species, which was described from Pensacola, and not elsewhere recorded, Professor S. F. Baird obta specimens in Charleston Market, South Carolina, Apri

7. *Reinhardtius hippoglossoides* (Walb.) Gill.

The southern range of this Arctic species has been to latitude 42° N. Fishermen take them frequently gully between Le Have and George's Banks, at depth than 200 fathoms. They appear to inhabit the abrupt slopes of the banks beyond and below the range of the this fact, together with the uniform dark coloration of th side of the body, seems to indicate that its habits dif those of other pleuronectoid fishes.

8. *Chænopsetta oblonga* (Mitch.) Gill.

One specimen was trawled August 15, 1878, in the h Gloucester. It has not previously been recorded in M setts Bay except at Provincetown, where Captain obtained it in 1846, and where it has since been occa observed.

9. *Macrurus Bairdii* Goode and Bean.

The unique specimen of this species has been supple by three additional ones captured August 27, 1878, fi miles off Eastern Point Light (Cape Ann), E. ¾ S., in 1 oms, which is within two or three miles of the locality a the type was secured.

10. *Macrurus rupestris* Bloch.

Many specimens have been brought in by fisherm testimony is that it is abundant in the deep waters o and the more northern banks.

11. *Phycis Chesteri* Goode and Bean.

Three specimens of a new species of *Phy* the trawl-net thirty-three to forty-two m Cape Ann in 110 to 140 fathoms.

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to the vertical from the posterior margin of the orbit. The barbel scarcely equals half the diameter of the orbit.

The vent is situated under the nineteenth ray of the second dorsal, equidistant from snout and tip of caudal.

The anal is inserted behind the vent at a distance equal to the length of the second anal ray; it has a considerable depression in its middle and terminates in a line with the end of the second dorsal.

The pectoral is slightly more than four fifths as long as the head and extends to the vertical from the ninth ray of the second dorsal. Its length equals greatest height of body.

The longest ray of the ventral is about seven-eighths of the length of the head, and extends half way to the vent.

Radial formula: D. 4, 53; A. 40; V. 6. Scales in lateral line about 115; above lateral line 11.

13. *Hypsiptera argentea* Günther.

A single individual was taken at the surface, May, 1878, about forty miles off Cape May, New Jersey, by Captain Robert H. Hurlbert of Gloucester. This is an addition to the fauna of the Western Atlantic.

14. *Lota maculosa* (Le Sueur) Richardson.

After close study of a large series of specimens representing every locality from which species of *Lota* have been described in America and many places in Europe, Dr. Bean agrees with late writers in referring all the American species, so called, to *Lota maculosa.* This species, in the skeletons examined, has sixty-four vertebræ. The European variety, in two examples studied, shows sixty-one vertebræ. Dr. Günther gives the number as sixty. On the basis of this difference in the number of vertebræ Dr. Bean, for the present, separates the European from the American burbot as a variety with the name *Lota maculosa* (LeSueur) Rich. var. *vulgaris* Jenyns. Further observation of the number of vertebræ is very desirable.

The specific name *maculosa*, formed by LeSueur in 1817, seems to have priority. Walbaum's *Gadus lacustris* was evidently a catfish.*

The name *vulgaris*, though attributed to Cuvier and Jurine was not used nor claimed until in 1835 by Jenyns in his Manual of the Vertebrate Animals.

15. *Lycodes Verrillii* Goode and Bean.

Taken sparingly in from 73 to 114 fathoms off Cape Ann, at one time within seven miles of Thatcher's Island.

* See the description and also "Mathemeg" in Rich. Faun. Bor. Amer., p. 135, and Jordan, Bull. x, U. S. Nat. Mus., p. 84.

Professor Robert Collet* has considered this species identical .th his *L. Sarsii;* but even the comparative tables which he troduces in support of this position show that the two species e clearly distinct.

'. *Leptoblennius serpentinus* (Storer) Gill.

Taken occasionally in seventy fathoms or more.

. *Anarrhichas lupus* L.

Specimens of an *Anarrhichas* with brown cross bars instead spots and which cannot in any way be distinguished from e European species, have been taken during the past season. 'e add this species to the faunal list without expressing an)inion as to the validity of the species *A. vomerinus* Agassiz.

'. *Eumicrotremus spinosus* (Fabr.) Gill.

Three specimens were secured, September 2, 1878, seventeen ıd three-quarter miles S. E. ½ E. from Eastern Point Light, ıpe Ann, in twenty-three to twenty-eight fathoms.

'. *Trichidion octonemus* (Girard) Gill.

Of this species, hitherto known only from Texas, the United :ates National Museum has lately received a specimen colcted by Mr. Silas Stearns at Pensacola, Florida.

'. *Orcynus pelamys* (Linné) Poey.

A specimen of the oceanic bonito was taken in July or ugust, 1877, off Provincetown, Massachusetts, and presented 7 Mr. Jas. H. Blake to the Museum of Comparative Zoology. n addition to our fauna.

. *Caulolatilus microps* Goode and Bean.

A specimen two feet three inches in length, taken March 18, 378, on the Snapper Bank, off Pensacola, Florida, in thirtyve fathoms of water, was received from Mr. Silas Stearns. or a full description see Proc. U. S. National Museum, 1878, 42.

:. *Cynoscion regalis* (Bloch) Gill.

Three individuals have been taken during the summer in apt. Webb's trap near Thatcher's Island, off Cape Ann. It ıd not previously been recorded farther north than Provincewn, Massachusetts.

ı. *Menticirrus nebulosus* (Mitch.) Gill.

One specimen was secured in the summer of 1878 by Captain 'ebb in the trap just referred to. Provincetown has been eretofore its recorded northern limit.

* Fiske fra den norske Nordhavs—Exped. 1876–77, Christiania Vidensk.—lsk. Forhandl. 1878, No. 4.

24. *Stenotomus argyrops* (Linné) Gill.

The northern range of the scup is extended to Thatcher's Island, off Cape Ann, where it has recently been taken in considerable numbers by Captain Webb.

25. *Sargus Holbrookii* Bean.

Six specimens of this new species, from Savannah Bank, were sent to the United States National Museum, March 29, 1878, by Mr. Goode. Numerous individuals apparently belonging to the same species were collected at Beaufort, North Carolina, by Professor D. S. Jordan during the summer of 1878.

Diagnosis: Body ovate, compressed, a very slight protuberance above the upper anterior margin of the orbit, and a very marked one in the supra-occipital region. Distance from origin of ventral to origin of spinous dorsal is about two-fifths of total length to end of middle caudal rays.* Least height of tail is about equal to length of upper jaw.

Length of head is contained three and three-quarter times in total. The interorbital area is slightly less than one and a half times the long diameter of eye. The length of snout is one-tenth of total length and about equals that of mandible. The eye is contained nearly four and one-fifth times in length of head.

The longest dorsal spine is contained from eight and one-half to ten times in total length of body.

The distance of anal from snout is contained one and five-eighth times in total length. Longest anal spine equals one-twelfth of total length.

The length of middle caudal rays equals that of snout.

The distance of pectoral from snout is contained three and one-half times, and its length about three times in total length.

The distance of ventral from snout slightly exceeds the length of pectoral. Length of ventral averages nearly one-fifth of total length.

Radial formula: B. vi; D. xii, 13–14; A. iii, 13–14; P. 15–16; v, 1, 5.

Scales: 8–60 to 62–16.

Teeth: eight incisors in each jaw, their greatest width equal to half their length. Three rows of molars above, two below, with sometimes a tendency to increase the number of rows.

For a full description, see Proc. U. S. National Museum, 1878.

26. *Rhomboplites aurorubens* (Cuv. and Val.) Gill.

A specimen of this species, hitherto known only from the West Indies was secured in May from Mr. C. C. Lesley, of

* This length is the basis of comparison for all my measurements of this species.

iarleston, South Carolina, another was collected at Pensacola, orida, by Mr. Silas Stearns a few days later.

. *Lutjanus Blackfordii* Goode and Bean.

The "red-snapper" of the Southern Atlantic and Gulf coasts oves to be distinct from the West Indian species with which had previously been confused. It was named in honor of :. E. G. Blackford of New York City, a gentleman who has idered many important services to American ichthyology. ill descriptions of this and the following species may be ind in the Proceedings of the U. S. National Museum.

. *Lutjanus Stearnsii* Goode and Bean.

The "mangrove snapper" of the Gulf of Mexico proved to new and was named in honor of Mr. Silas Stearns of Pensala, by whom the only known specimen was collected. *Rhomplites aurorubens*, mentioned above, is known at Charleston the "mangrove snapper," at Pensacola as the "bastard iapper."

). *Epinephelus Drummond-Hayi* Goode and Bean.

This magnificent species was first discovered at the Bermudas 1 1851, by Col. H. M. Drummond Hay, C.M.Z.S., by whom a ketch and partial description were prepared. The National Iuseum has lately received two specimens from Florida, one rom Mr. Blackford, collected at the Keys, the other from Mr. itearns at Pensacola. The species attains the weight of fifty ounds or more.

0. *Epinephelus niveatus* (Cuv. and Val.) Poey.

This species has been taken twice at Newport, Rhode Island, y Samuel Powel, Esq. The first specimen, a young individual, was made the type of the genus *Hyporthodus** by Professor Gill. A comparison of *Hyporthodus flavicauda* Gill vith Cuban specimens of *Epinephelus niveatus* proves their dentity. The second specimen was received from Newport in 1877. It has not been recorded elsewhere on the East coast.

1. *Roccus lineatus* (Bl. Schn.) Gill.

The "rock-fish" is taken in winter in the Altamaha River, n considerable numbers. South of this region its occurrence s extremely rare. Two were observed in the St. Johns River, Florida, in 1874; and in May, 1878, a stray individual was sent by Mr. Stearns from Pensacola.

12. *Remoropsis brachyptera* (Lowe) Gill.

Two specimens of this rare species have been obtained from fishing schooners. One was found clinging to the side of a

* Proc. Acad. Nat. Sci. Philad., 1861, pp. 98–99.

sword-fish harpooned in the channel southwest of George's Bank, another on the deck of a halibut-trawler fishing in the gully northeast of George's Bank, at a time when sword fish were being taken on the trawls. This species may very probably be a parasite peculiar to *Xiphias*, as the allied species, *Rhombochirus osteochir* is to *Tetrapturus albridus.*

33. *Belone latimanus* Poey.

The occurrence of a single specimen of this West Indian form in Buzzard's Bay, where it was obtained by the Commission in 1875, has already been recorded (Proc. U. S. National Museum, i, 1878, p. 6.) Several additional specimens from North Carolina or Chesapeake Bay, were obtained in Fulton market, New York, June 1, 1878.

34. *Belone hians* Cuvier and Valenciennes.

In company with the preceding were several specimens of this species hitherto recorded only from Bahia, the West Indies, and the Bermudas.

35. *Fundulus seminolis* Lesueur.

This species, long lost sight of, was collected in quantity by Professor Baird on the upper St. Johns River.

36. *Lucania parva* (Baird and Girard) Bean.

The *Cyprinodon parvus* of Baird and Girard should be referred to the genus *Lucania* Girard. The species is recorded only from Beesley's Point, New Jersey, Sinepuxent Bay, Maryland, Greenport, Long Island and Noank, Connecticut. (Bean.)

37. *Alepidosaurus ferox* Lowe.

Six specimens of this species are now on record in the United States—one in the collection of the Boston Society of Natural History and five in the United States National Museum. All of these have been captured within the limits of lat. 41° and 44° and at depths of 200 to 400 fathoms.

The first capture of *Alepidosaurus* in the Western Atlantic, was by Captain D. C. Murphy of the schooner Centennial in July, 1877, in 200 to 300 fathoms. Lat. 43° 46′ N.; long. 59° 19′ W.

38. *Salmo salar* L.

The salmon has been transported by the Commission of Fisheries to the rivers of the Middle States, to many points in the Mississippi valley and to the California coast. It may be regarded as acclimated in the Hudson, Delaware and Susquehanna Rivers, and re-acclimated in the Connecticut.

Brevoortia tyrannus (Latrobe) Goode.

he common menhaden was described under the name *pea tyrannus* by Latrobe in 1802, and the specific name then posed has priority over all others. An extended study of species of this group indicates that the *B. tyrannus* occurs the coast of Brazil, as far south as Bahia, and that Spix's *oanodon aureus* is specifically identical and should be in-led as a subspecies, *B. tyrannus* subspecies *aurea.*

Brevoortia patronus Goode.

. species occurring at several points on the north shore of Gulf of Mexico, from the mouth of the Rio Grande to sacola, Florida, where Mr. Stearns observed it in great ndance.

Alosa sapidissima (Wilson) Storer.

'hrough the agency of the United States Commission of ieries the common shad has been introduced into most of rivers flowing through the Southern States into the Gulf of cico, and may now be considered a member of the fauna of ; region, its range south and west having been extended r at least twelve hundred additional miles of coast line. It lso acclimated in California.

Pomolobus pseudoharengus (Wilson) Gill.

.bundant in Lake Ontario, Cayuga and Seneca Lakes, New ·k. The variety *lacustris,* founded on Cayuga Lake specimens Professor Jordan, is precisely like the average coast alewife. er careful measurements of numerous lake and coast speci-is I am unable to separate them. (Bean.)

Nemichthys scolopaceus? Richardson.

. single specimen nineteen inches long, of a curious eel-like was obtained from a fisherman who took it, living, from stomach of a cod fish caught on George's Bank in February, 5, in forty-five fathoms. Another, preserved in the collec-ı of the Cape Ann Literary and Scientific Association at ucester, was picked up on the deck of a cod vessel. It be-gs to the genus *Nemichthys* described by Sir John Richardson n a specimen collected by the exploring ship Samarang in South Atlantic. Only one species has been described, the e was from the South Atlantic. Another specimen of the us was taken at Madeira and described by Lowe under the ne *Leptorhyncus Leuchtenbergii.* Günther considers it to be ntical with *N. scolopaceus.* The American fish is at present gned to the same species. The family *Nemichthyidæ* is new he Western Atlantic.

44. *Amia calva* L.

The range of the mud-fish has not hitherto been recognized to extend south of Charleston, South Carolina, whence Garden sent specimens to Linnæus. It occurs abundantly in the St. Johns River, Florida, and Mr. S. C. Clarke found it in Spruce Creek, a tributary of Halifax River, about lat. 28°.

45. *Chimaera plumbea* Gill.

Within the past twelve months seven individuals have been secured—one by the Boston Society of Natural History and six by the United States National Museum:

The first specimen was taken by Captain D. C. Murphy of the schooner Centennial in July, 1877, in 200 to 300 fathoms, lat. 43° 46′ N., long. 59° 19′ W. Others have since been taken within the latitudes 42° and 44° N. and in water from 200 to 350 fathoms deep.

46. *Torpedo occidentalis* Storer.

Taken occasionally near Thatcher's Island, off Cape Ann, by Captain Webb, in his trap. A specimen was taken at Lanesville, Massachusetts, July 13, 1878, the only instance of its occurrence to the northward of the point of Cape Ann.

47. *Hypoprion longirostris* Poey.

A West Indian species; collected in the Gulf of Mexico, by Dr. J. W. Velie, of Chicago, and sent to Washington for identification.

48. *Centroscymnus cœlolepis* Bocage and Capello.

This species was described from the coast of Portugal. It is recorded, also, from Madeira. Three specimens were presented to the United States National Museum, August 26, 1878, by the crew of the schooner Marion, who captured them on the Nova Scotia banks, the first specimens known from the Western Atlantic.

49. *Centroscyllium Fabricii* (Reinh.) Müller and Henle.

A Greenland species. One individual was received from Captain Jos. W. Collins, schooner Marion; locality same as the last. This species is new to the fauna of the Western Atlantic. Both this and the preceding are called by the fishermen "Black Dog fish."

50. *Ginglymostoma cirratum* (L. Gm.) Müller and Henle.

An adult specimen was taken in the Gulf of Mexico, by Dr. J. W. Velie of Chicago. A young individual was captured by Mr. Otto Lugger in Chesapeake Bay.

Gloucester, Mass., September 7, 1878.

V.—*Note on the Brightness and the Stellar Magnitude of the l Saturnian satellite*—Tethys; by EDWARD S. HOLDEN.

ɪicated by permission of Rear Admiral JOHN RODGERS, U. S. N., Superintendent U. S. Naval Observatory.]

November 20, 1878, I was observing *Saturn's* satellites ɪe 26-inch refractor, using an eye-piece magnifying 400 ɜrs. Four satellites were nearly in the plane of the ring ɪn angle 94°·2). They were

Tethys; p=265°,	s=35″; (estimated.)
Dione; p= 94 ,	s=60″; (")
Titan; p= 94±,	s=over 150″ (estimated.)
Enceladus; p=92 (est),	s=31″·13 (measured.)

bout $8^h\ 30^m$ as I had just completed the measure of the e of *Enceladus*, the sky became covered with flying which continually passed over *Saturn*, partially obscur- planet and dimming the light of the satellites. The were probably forming and disappearing constantly, as was full of moisture, the difference of the wet and dry ɪermometers being less than 1° F.

I noticed before beginning to observe that large portions sky were alternately obscured and clear, evidently owing clouds formed on the spot.

disappearance or dimming was gradual and it seemed to a photometric experiment similar to that tried by ɪn the nebula of *Orion* during twilight, when the order appearance of the details, with the times, were noted.* ɔrdingly, Mr. Anderson, assistant, watched *Saturn* with ɛed eye, looking along the telescope as a guide at the while I watched the appearance of the satellites through ɪatorial. The interior of the dome was perfectly dark.

, cloud gradually (and as nearly as could be judged uni-) darkened *Saturn* as seen in the telescope, the appear- vere carefully noted and when the planet disappeared to ɛed eye Anderson called "now."

his instant I endeavored to note the visibility of the ɜs.

ladus, which was faint at the best, always disappeared this instant. In four (tolerably satisfactory) experiments found that *Tethys* disappeared in the telescope at the nstant that *Saturn* did to the naked eye. In several ɪrances I found that *Dione* reappeared in the telescope

* Annals Harv. Coll. Obs., vol. v, p. 164, etc.

just before *Saturn* appeared to the naked eye; and that *Tethys* was seen almost at the same time, or a very little after this. When *Saturn* was just appearing or disappearing *Titan* was as bright in the telescope as *Dione* when no clouds were present.

Dione was always a little brighter that *Tethys*. The southern edge of the belt in the southern hemisphere of *Saturn* vanished *about* at the same time as *Enceladus*. This observation is, however, not so precise as those on *Tethys*.

As many appearances and disappearances as possible were observed and the result of them all is that *Tethys* was as bright to my eye in the telescope as *Saturn* was to Anderson's unassisted eye. It may be mentioned that Anderson under good circumstances can see *Uranus* with the naked eye, and by experience I have learned that my eye is well suited to seeing faint satellites like those of *Uranus* and *Neptune*. I believe that our eyes used as in this experiment were as nearly equal as any could be.

The sky became totally cloudy before I could measure the the position of *Tethys*. From Prof. Newcomb's MS. tables the time of West elongation is $12^h.4$ Wash. m. t.

These experiments enable us to determine approximately, the relative brilliancy of *Tethys*, in this part of its orbit, with *Saturn*. Assuming the diameter of the pupil of the eye at $0{\cdot}2^{in}$ the relative amount of light received by Anderson's eye from *Saturn* and through the telescope from *Tethys* are as (26·00 inches)^2 to (0·2 inches)^2, or as 16,900 to 1. So that the immediate result of these experiments is that *Tethys* was at that time $\frac{1}{16900}$th part, or 0·00005917 as bright as *Saturn*, including both ball and ring.

From the table given by Zöllner in *Photometrische Untersuchungen*, p. 200, it follows that if *Saturn* had been without his ring, the light from the ball alone would have been 0·9356 (log. 9·9711) of the light of ball and rings combined. Hence if H_1 is the light from the ball alone, the light received from *Tethys* was $\dfrac{1}{16{,}900}\cdot\dfrac{H_1}{0{\cdot}9356} = 0{\cdot}00006323.\ H_1$ (log. $5{\cdot}8009\ H_1$).

If H_1 is the brilliancy of a planet at a time when its distance from the sun is r_1 and from the earth ρ_1; and if d is the true diameter of the planet in miles and A a constant depending on the nature of its reflecting surface then

$$H = A.d^2\left(\frac{1}{r_1^2.\rho_1^2}\right)^*$$

At another time, $H_2 = A.d^2.\left(\dfrac{1}{r_2^2.\rho_2^2}\right)$ and

$$H_1 : H_2 = r_2^2\,\rho_2^2 : r_1^2.\rho_1^2.$$

* See Stampfer: Sitzungsber. der k. Acad. d. Wiss. Berlin, vol. vii, 1851, p. 760.

For November 20, $8^h.5$ Wash. m. t., log. r_1 = 0·9787 and g. ρ_1 = 0·9554. The mean distance of *Saturn* is 9·5389 og. r_2 = 0·9795) and the log. of its mean distance from the rth is log. ρ_2=0·9789. Thus the brilliancy of *Saturn* was reater on November 20 than at its mean opposition in the tio of 1·118 to 1, or H_1 = 1·118 H_2. Thus *Tethys* = 000071 H_2 or in words, *Tethys in this particular part of its bit has seventy-one millionths of the brilliancy of the ball of aturn at mean opposition.*

Zöllner has determined (op. cit. p. 145) the relative brilliancy *Saturn's* ball at mean opposition of *Capella* to be *Saturn* = 431 *Capella*; (log. 9·6345). Hence *Tethys*=0·000030 *Capella*; og. 5·4840).

From this we can determine the stellar magnitude of *Tethys.* If the light of a first magnitude star (as *Capella*) be assumed s 1·000 and if the light-ratio be δ (0·40) and if m be the magitude of the star on Argelander's scale, then δ^{m-1} = the light f the star in terms of the light of the first magnitude star as nity. For us δ^{m-1} = 0·000030 or m = 12·3 approximately. On Struve's scale m' = 11·8. On Herschel's scale m'' = 12·5.]

The resulting stellar magnitude of *Tethys* on Argelander's scale being as we have seen 12·3 it should be just visible with a telescope of a little over four inches aperture.* This I tested on November 23d, and I find that with four inches aperture *Tethys* was just barely visible at elongation (East) with a power of 200 diameters when *Saturn* was in the field. When *Saturn* was put out of the field it was just steadily visible. With a power of 400 it was better seen, never totally disappearing. With an aperture of five inches on the finder and a power of thirty it was not seen. The appearances were the same to both Anderson and myself. These observations give a rough check on the preceding accurate ones, as the two methods agree better than could be expected. It also affords some evidence as to the eyes of the two observers.

If the relative brilliancy of the various satellites among themselves be measured, the foregoing observations afford a ready means of deducing their brilliancy in terms of a standard star like *Capella* and hence in terms of any standard star.

U. S. Naval Observatory, Washington, 1878, Nov. 25.

* See Pogson: Mon. Not. R. A. S., vol. xxi, p. 34. It is important to remember that in the application of Pogson's formula there is considerable uncertainty owing to the varying effects of different magnifying powers, and to other causes.

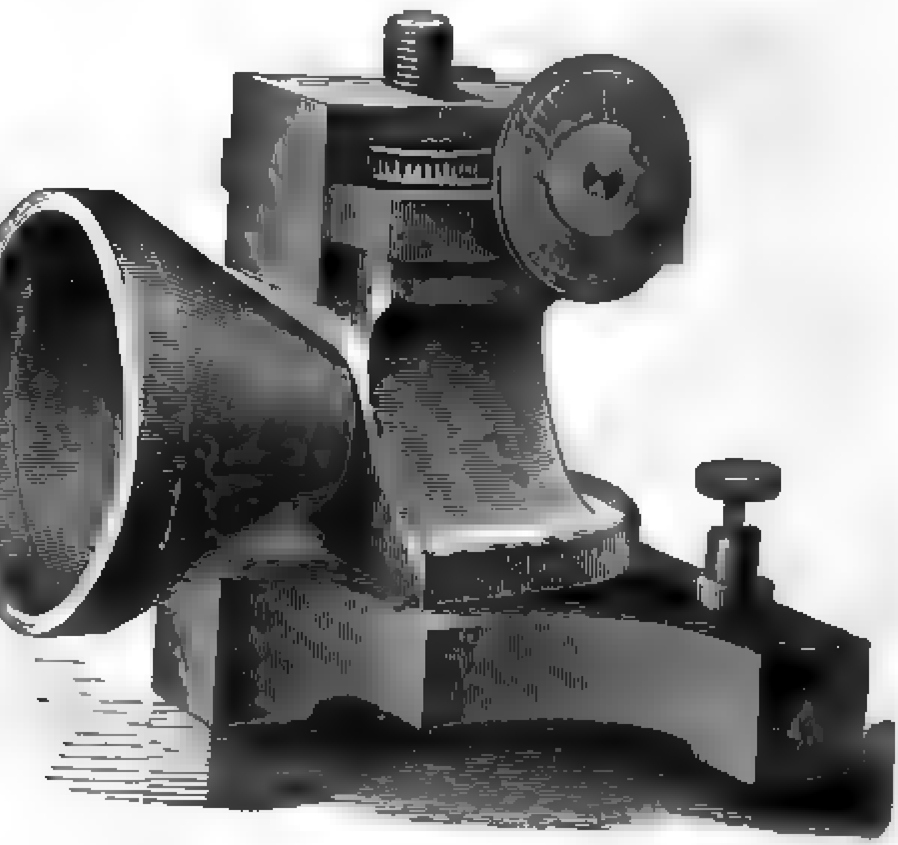
ART. V.—*On the use of the Tasimeter for Measuring the Heat of the Stars and of the Sun's Corona*;* by THOMAS A. EDISON, Ph.D.

To Professor Henry Draper M.D., Director of the Draper Eclipse Expedition:—

Dear Sir: The instrument which I used at Rawlins, Wyoming, during the solar eclipse of July 29, 1878, for the purpose of measuring the heat of the sun's corona, was devised by me a short time only before that event; and the time was insufficient to allow me to give it as thorough a test as was desirable to ascertain its full capabilities and characteristics.

This instrument I have named the tasimeter, from the Greek words *τασις*, extension, and *μετρον*, measure, because primarily the effect is to measure extension of any kind. The form of instrument which I used is shown in the annexed wood-cut (fig. 1.)

1.

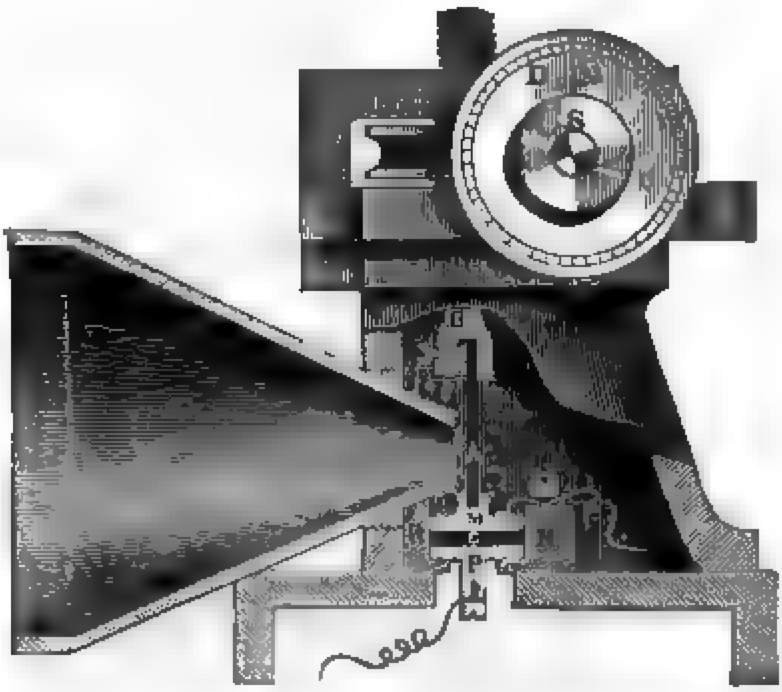


With this instrument was used a Thomson's reflecting galvanometer, on a tripod, and having a resistance of three-fourths of an ohm. The galvanometer was placed in the bridge wire of a Wheatstone balance, two of the branches of which had constant resistances of ten ohms each, while of the other two one had a constant of three ohms, and the other contained the tasimeter which was adjusted by means of the screw to three ohms. When thus balanced if the strip of vulcanized rubber placed between the fixed point and the carbon button (seen in fig. 2)

* Read, by permission of Dr. Draper, at the St. Louis meeting of the American Association.

xposed to heat from any source, it expanded, producing ire upon the carbon button, decreasing its resistance and ɔying the balance; a current was thus allowed to pass

2.



gh the bridge wire containing the galvanometer, the nt of this current of course being proportional to the ısion of the rubber and to the strength of the battery.
e form of instrument here described was only finished two before leaving for the west; hence I was unable to test it. ɛver, I set it up upon my arrival at Rawlins, but found t was a very difficult matter to balance so delicate an instru- as a reflecting galvanometer with one cell of a battery, gh such small resistances. In fact, I did not succeed in cing it at all in the usual way. Nor could it be balanced v way until I devised a method which I may designate tional balancing," when it became very easy to accomplish sult and also to increase the effect by using two cells in of a single one. This device consisted of a rheostat d of two rows of pins. The rows were about one-half an ıpart. A wire was connected from a pin on one row to a n the other row and so on, so that the current had to pass gh the whole length of the wire, which was No. 24 gauge our feet long. This was used as a shunt around the gal- neter. A copper wire connecting all the pins of one row l to reduce the resistance to zero. When the galva- ter was then shunted, a very feeble current passed through f the spot of light was not at zero it was brought there by · increasing or decreasing the pressure upon the vulcanite e tasimeter by the adjusting nut. When thus brought to he copper wire of the shunt rheostat was taken off of one

pin, thus increasing the resistance of the shunt perhaps to one-fiftieth of an ohm. The spot of light was generally deflected nearly off of the scale. The light was again brought to zero by varying the resistance of the tasimeter, and another one-half inch of wire included in the shunt, another deflection and another balance was obtained by the tasimeter. Thus by gradually increasing the delicacy of the galvanometer by increasing the resistance of the shunt and balancing at every increase, the whole of the current was allowed to pass through the galvanometer and the shunt taken off. When this point was reached the damping magnet or director was in close proximity to the case of the galvanometer. To increase its delicacy to the fullest extent it became necessary to raise the director to the top of the rod. This was done by raising it cautiously a quarter of an inch at a time, bringing the spot of light to zero each time by the tasimeter.

In order to form some idea of the delicacy of the apparatus when thus adjusted, a preliminary experiment was made on the evening of the 27th, with the star Arcturus. The tasimeter being attached to the telescope, the image of the star was brought on the vulcanized rubber. The spot of light from the galvanometer moved to the side of heat. After some minor adjustments, five uniform and successive deflections were obtained with the instrument, as the light of the star was allowed to fall on the vulcanite to produce the deflection, or was screened off to allow of a return to zero.

It was in this condition when the eclipse occurred. The tasimeter was placed in a double tin case, with water at the temperature of the air between each case. This case was secured to a Dollond telescope of four inches aperture. No eye-piece was used. At the moment of totality the spot of light was slowly passing towards cold. When I withdrew a tin screen and allowed the edge of the luminous corona to fall upon the rubber, the spot of light stopped, went gradually off of the scale towards heat, its velocity accelerating as it approached the end.

The time required for the light to leave the scale was from four to five seconds.

I interposed the screen and endeavored to bring the light back to zero, but I was unsuccessful. Had I known that the heat was so great I should have used a platinum strip in place of the vulcanite, and decreased the delicacy of the galvanometer by the approach of the damping magnet. I then should doubtless have succeeded in getting two or more readings, and afterwards by comparison with bodies of known temperature should have obtained a near approach to the temperature of the sun's corona.

Respectfully yours, THOMAS A. EDISON.

Menlo Park, N. J., August 15, 1878.

ART. VI.—*Description of a Paper Dome for an Astronomical Observatory;* by Professor DASCOM GREENE, Troy, N. Y.

AN astronomical observatory has recently been erected for the Rensselaer Polytechnic Institute, through the liberality of Mr. E. Proudfit of this city. In maturing the plans, and supervising the erection of the building, I have introduced an improved method of constructing revolving domes, a brief account of which may not be without interest.

While making the preliminary inquiries, I ascertained that a dome of the dimensions required, constructed in any of the methods in common use, would weigh from five to ten tons, and require the aid of cumbersome machinery to revolve it. It therefore occurred to me to obviate this objection by making the frame-work of wood, of the greatest lightness consistent with the requisite strength, and covering it with paper of a quality similar to that used in the manufacture of paper boats; the principal advantages in the use of these materials being that they admit of great perfection of form and finish, and give extreme lightness, strength, and stiffness in the structure,—prime qualities in a movable dome. A contract was accordingly made with Messrs. E. Waters & Sons, of this city, the well-known builders of paper boats, for the construction of the dome, and they have carried out the undertaking with great skill and success.

The dome is a hemisphere with an outside diameter of twenty-nine feet. The frame-work consists primarily of a circular sill which forms the base, and two semi-circular arch girders set parallel to each other, four feet apart in the clear, and spanning the entire dome. These are firmly attached to the sill and kept in a vertical position by means of knee-braces. The sill and girders are of seasoned pine, the former being 8¼ inches wide by 3½ thick, and the latter each 4½ by 3 inches.

The paper covering of the dome is made in sixteen equal sections, such that when set up side by side, their bases on the sill, and their extremities meeting at the top, they form a complete hemispherical surface. The frame-work of each section consists of three vertical ribs of pine each 3¾ inches in width and ¾ of an inch thick, one at each side and one midway between, and meeting at the apex. The paper was stretched over this frame-work as follows:

A wooden model of full size being made of that portion of the dome included within one of the sections, with a surface truly spherical, the frame-work of a section was placed

in its proper position on the model, so that its outer edges formed part of the same spherical surface, and covered with shellac where it was to be in contact with the paper. The sheet of paper cut in the proper form was then laid on the model while moist, the edges turned down over the side ribs, and the whole placed in a hot chamber and left until thoroughly dry. In this way the several sections were dried off in succession over the same model. The paper used is of a very superior quality, manufactured expressly for the purpose by Messrs. Crane Brothers, of Westfield, Mass. Its thickness after drying is about one-sixth of an inch, and it has a structure as compact as that of the hardest wood, which it greatly excels in strength, toughness and freedom from any liability to fracture.

After being thoroughly painted, the several sections were ready to be set up side by side on the sill and connected together by bolting through the adjacent ribs. The space between the arch girders being left uncovered on one side from the sill to a distance of two feet beyond the zenith, the upper ends of the sections required to be cut off and accurately fitted to the girders. The joints between sections were made weather proof by inserting a double thickness of heavy cotton cloth saturated with white lead paint. The adjacent side ribs were then bolted firmly together through the paper and cloth, the lower ends attached to the sill by angle irons, the upper ends bolted to the girders, and the lower edge of the paper turned under the sill and securely nailed. The joints were afterwards painted over on the outside. As the entire surface exposed is free from nail holes or other abrasions in the paper, the structure promises with an occasional coat of paint to last for many years, and to form an effective and serviceable roof.

The 4-feet opening between the arch girders is covered by a shutter which is also of paper stretched over a wooden frame. With the exception of about two feet at the lower extremity, this shutter is in a single piece. Attached to its sides are a series of iron rollers which run on a railway track of band iron laid down on the girders, by which means the shutter can be moved over to the opposite side of the dome. The wooden sides of the shutter have iron flanges attached to their lower edges, which project under the railway tracks, making the whole weather proof. The shutter is opened and closed by means of a windlass and wire rope.

The weight of the dome and its appurtenances is about 4,000 pounds. It is supported on six 8-inch balls which roll between grooved iron tracks, and can be easily revolved by a moderate pressure applied directly, without the aid of machinery.

r. VII.—*On the Age of the Clay-slates and Grits of Poughkeepsie;** by T. NELSON DALE, Jr.

ɪ Mather's geological sections of the Hudson River valley† alternating argillaceous schists, slates and grits, on both s of the river, in the vicinity of Poughkeepsie are assigned ɪe Hudson River Group. This term was originally intended nclude the series between the Utica Slate below and the ina Sandstone above. These rocks would thus represent uppermost North American Lower Silurian.

ı the geological map drawn by Logan and Hall, and ended to the Report of the Canadian Geological Survey, rocks for some miles on both sides of the Hudson River, h of Rondout on the west side and of Rhinebeck on the side, and extending southward beyond Poughkeepsie, designated as Calciferous and Quebec. They are thus rred to the middle division of the North American Lower rian.

ana, referring to this subject, observes in his Manual of logy, ed. 1874, on page 184: "The extension of the Que- group southward, along the west side of the Green Moun- range, covers, according to Logan, a considerable part of v York east of the Hudson, the rock being part of the non- iliferous clay-slate (formerly called Hudson River slate) ch outcrops near Poughkeepsie, etc. The area is divided the west from that of the true fossiliferous Hudson River s (or Cincinnati series, as now called), by a great fault, which, inning near Quebec, crosses the Hudson near Rhinebeck, en miles north of Poughkeepsie. As these rocks have rded no fossils, the age is still doubtful." Again on page of the same work, he says, under the head of Cincinnati och: "In New York, the Hudson River beds include shales l sandstones. They are the Lorraine shales of Jefferson unty (the Pulaski shales of the New York Annual Reports), ntaining some thin beds of limestone. The slates along the dson River, to which the name was especially applied, have en proved to be in part Primordial, and part, probably of the ebec series."

These rocks have therefore been first assigned to the Trenton riod, then to the Canadian Period and afterwards declared

A paper containing the substance of this article, in a different form, and enti- "A contribution to the Paleontology of the vicinity of Poughkeepsie," was l by the author before the Poughkeepsie Society of Natural Science on Decem- 4th, 1878, and is being published in the Proceedings of that Society.

Nat. Hist. of N. Y., Part IV, Geology, by William W. Mather; Plates 16, 18, 46

unfossiliferous, and thus a question has been raised as to their real age.

In the spring of 1878, I discovered in a ledge of argillaceous schist, back of the observatory of Vassar College, and a few rods beyond the college fence, some fossil Brachiopoda. Shortly afterward I found others, together with Crinoid stems, at the first ledge of glaciated rock on the Stormville road, between Casper Creek and the first limestone ridge. Again in November and December of the same year, in ascending the first range of high hills which rises about a mile west of the Hudson* opposite Poughkeepsie, I came across a large outcrop of argillaceous schist, containing an abundance of Brachiopoda and Crinoid stems. After it had become known that fossils were to be found in the vicinity of Vassar College, several of the students found some, and Mr. H. Booth of Poughkeepsie, collected a number of Brachiopoda and Crinoid stems at the ledge back of the observatory. On another visit to the locality on the base of Marlborough Mountain, I found a univalve shell and Fucoids.

I am indebted to Mr. James Hall, the State Paleontologist, for the identification of the fossils from these localities. They are: *Orthis testudinaria* Dalm.; *Orthis pectinella* Con.; *Leptæna sericea* Sow.; *Strophomena alternata* Con.; *Buthotrephis subnodosa* Hall.

The cast of the univalve hardly admits of perfect determination, but it strongly resembles that of *Bellerophon bilobatus*. The Crinoid stems measure from one to three millimeters in diameter. There are from thirty-five to forty grooves on the ends, radiating from the central tube to the circumference. The surface is round and smooth. Casts of the central tube, and of the spaces between the joints are preserved, and might easily be mistaken for stems with annular corrugations on the exterior.

In some parts of the rock, Crinoids are very abundant, in others *Orthis testudinaria* forms a conglomerate. *Leptæna sericea*, *Orthis testudinaria* and the Crinoid stems are characteristic of both the Vassar College locality and of that on the west of the Hudson. The Brachiopoda are represented by internal casts, impressions of both exterior and interior, and by the shell itself in a greatly altered state. Sometimes the calcareous shell is preserved with but little alteration. The more minute striæ of *Leptæna sericea* can be counted in some specimens. Nearly all the fossils are more or less distorted. The general character of the rock is the same on both sides of the river. There are irregular alternations of grit, clay slate and shale, in some places,

* I take this hill to be a continuation of what Mather calls Marlborough Mountains.

with thin strata of limestone. The grit is sometimes slightly calcareous.

The geological significance of these fossils is evident. I quote, however, from Hall:* "*Orthis testudinaria:* This species rarely, or never, appears in the Utica slate, but reappears near the middle of the Hudson River shales, and continues nearly to their termination, being abundant at Turin, Lorraine, Pulaski, and other places. It is more rarely found in the vicinity of the Hudson River and in the Mohawk valley." p. 288. "*Orthis pectinella:* This species, though not usually abundant, occurs nevertheless in nearly every part of the Trenton limestone, though unknown to me in the Hudson River group." p. 123. "*Leptæna sericea:* The thin layers in the lower part of the Trenton limestone are often entirely covered with the perfect shells or separated valves of this species. It occurs in all localities of the Trenton limestone. It also reappears in the Hudson River group, being in some localities very abundant." p. 110. "*Strophomena alternata:* This is one of the species, which, commencing its existence prior to or at the epoch of Trenton limestone, continues in great numbers throughout the rock, and, though not appearing in the Utica slate, reappears in the Hudson River group in immense numbers, several thin strata in the upper part of this group being composed almost entirely of the shells of this species." p. 105. The occurrence of these fossils in these localities would then establish the fact that the clay-slates and shales in the vicinity of Poughkeepsie, on both sides of the river, are fossiliferous and that they very probably belong to the Hudson River group, as indicated by Mather in 1843, certainly to some member of the Trenton Period. These facts also speak in favor of the retention of the term Hudson River group as advocated by Hall.†

Poughkeepsie, N. Y., Dec. 12, 1878.

Supplementary Note.—A visit to Marlborough on the west bank of the Hudson River, about eight miles south of Poughkeepsie, has just yielded the following results. In an outcrop of argillaceous schist near the river: *Orthis testudinaria*, *Orthis pectinella*, *Leptæna sericea* and Crinoid stems In a slightly calcareous grit at the southern extremity of Marlborough Mountain, there called Break-neck Hill, about three miles west of the river at this point: *Orthis testudinaria.*

Poughkeepsie, N. Y., Dec. 16, 1878.

* Nat. Hist. of N. Y. Paleontology, vol. i.

† See Note upon the History and Value of the term Hudson River group in American Geological Nomenclature, by JAMES HALL, of Albany, N. Y., in Proceedings of the Amer. Assoc. Adv. Sci., 1877. This Journal, vol. xvi, p. 482.

ART. VIII.—*On the Electrolytic Estimation of Cadmium;* by EDGAR F. SMITH, Ph.D.

IN a recent article published in this Journal (vol. xvi, Sept., 1878), Professor F. W. Clarke calls attention to the estimation of cadmium by electrolysis, which, however, proved unsuccessful—the cadmium being indeed thrown out of the solution, but in such a form as to enclose impurities; yielding consequently unsatisfactory results.

Out of curiosity to see what might be effected by substituting some other salt for the chloride, I employed an acetate solution and met with success, as the following experiments show:

I. ·1450 grams cadmium oxide were dissolved in acetic acid, the excess of the latter evaporated upon a water bath and then the platinum crucible about half filled with water and placed upon a copper ring connected with the negative pole of a two-cell Bunsen battery, while joined to the wire leading from the positive pole was a strip of platinum foil extending into the acetate solution. The deposition of the cadmium upon the platinum crucible was regular and in a perfectly crystalline grayish white layer. In about three hours the separation was complete. The cadmium was first washed with distilled water, then with alcohol, and finally with ether. It was dried over sulphuric acid. The metallic cadmium weighed ·1270 grams, corresponding to 87·58 per cent Cd. The calculated percentage of metal in the oxide is 87·50.

II. ·2046 grams cadmium oxide placed in a small, rather broad platinum crucible, were dissolved in acetic acid, and after expelling the excess of the latter, water was added—the solution, however, remaining rather concentrated. The platinum vessel was connected with the negative pole of a bichromate battery. To the copper wire of the positive pole was attached a platinum wire from which was suspended a small platinum crucible, which dipped into the solution in the larger vessel. The space between the walls of the two crucibles was not more than an eighth of an inch; only two cells of the battery were employed. The deposit of the cadmium here as in the first experiment was perfectly crystalline and metallic in appearance. Not the slightest trace of spongy metal was visible. The separation was finished in about the same time as in (I). The metal was washed and dried as above. Found ·1790 grams metal, corresponding to 87·48 per cent Cd.

From various experiments made by me I find that good results may be obtained constantly by observing the following: 1st. Work with rather concentrated solutions of the acetate. 2d. Employ a sufficient number of cells of either battery, to give a rapid and rather energetic current.

Laboratory of the University of Pennsylvania, October 31, 1878.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

On the New Element, Philippium.—DELAFONTAINE has inced the discovery of a new element, in the earths obtained the mineral samarskite, to which he has given the name *ppium*, after Philippe Plantamour of Geneva. The oxide e new metal, philippia, having the symbol PpO, is yellow ias a color and a molecular weight intermediate between , and terbia. Admitting it to be a protoxide, the atomic it of the metal would be between 90 and 95. Philippium te crystallizes easily in small brilliant rhomboidal prisms less le than yttrium formate. The oxalate is more soluble in acid than the terbium salt, less so than that of yttrium. itrate becomes dark yellow on heating it to fusion, the ter- and yttrium salts remain colorless. Concentrated solutions ilippium show a spectrum containing a magnificent absorp- band in the blue-indigo ($\lambda = 4500$ about) intense, broad, and defined, which is characteristic of it, not being found in the ra of terbium, yttrium or erbium. Two other narrower s appear in the green, the more refrangible of which appears ong to erbium, the less to philippium. Observing the spec- of terbium solutions with sunlight and through blue glass, k band was observed in the violet ($\lambda = 4000$ to 4050 about) half as broad as the philippium band. The author questions ier it really belongs to terbium as Soret supposes, or to a lement, between terbium and erbium.—*C. R.*, lxxxvii, 559, 1878. G. F. B.

On the New Element, Decipium.—DELAFONTAINE has reported iscovery of a second new element in the mineral samarskite North Carolina, to which he gives the name *decipium*, from iens, deceiving. The oxide, if the formula DpO be assigned has a molecular weight of 122; it has not been obtained iently free from didymium oxide to enable the author to say t is white, though its salts are colorless, the acetate crystal- easily, being less soluble than that of didymium but more so that of terbium. Potassio-decipium sulphate is but slightly le in a saturated solution of potassium sulphate, though it ves easily in water. The nitrate gives an absorption spec- consisting of at least three bands, in the blue and the in- The most refrangible of these is a little less broad than of philippium, is dark, and corresponds in its center to a length near 4160, being about half way between G and H. ier didymium nor terbium gives bands in this region. The d band is narrow, intense, not defined on its edges, and is e less refrangible part of the blue, corresponding to a wave h of 4780; nearly in the same place as one of the didymium s, but far more intense. Finally a little to the right and

nearly to the limit of the blue and green is an appearance of the third. The earths of samarskite as now known are given by the author in the following tabular form:

Name.	Color.	Molec. weight.		Wave length of Charac. band.
Yttria	White	$YO = 74{\cdot}5$	(Delafontaine)	None.
Erbia	Rose	$ErO = 130$	(Bunsen-Clève)	520–522
Terbia	Orange	$TbO = 114–115$	(Delafontaine-Marignac)	400 about
Philippia	Yellow	$PpO = 90$ about	(Delafontaine)	449 about
Decipia	White ?	$DpO = 122$ about	(Delafontaine)	416
Thoria	White	$ThO_2 = 267{\cdot}5$	(Delafontaine)	None.
Didymia	Brownish	$DiO = 112–114$	(Marignac-Clève)	572–577
Ceria	Pale yellow			

He also calls attention to the numerical relations between the atomic weights, thus: Yttrium $= 58$; Philippium $= 74$ or $58+2\times8$; Terbium 98 or $58+5\times8$; Decipium 106 ? or $58+6\times8$; and Erbium$=114$ or $58+7\times8$.—*C. R.*, lxxxvii, 633, Oct., 1878.

G. F. B

3. *On the New Element, Mosandrum.**—At a recent meeting of the French Academy (November 25th, 1878), a note by Dr. J. Lawrence Smith was presented, in which he claimed for himself priority in having been the first to call attention to the absence of cerium oxide, and to the new characters of certain earths, in the North Carolina samarskite, and to have described one of these under the name Mosandrum.

4. *On the New Element, Ytterbium.*—Marignac has described some of the compounds of a new element, found in the Ytterby mineral gadolinite; it is associated with yttrium and erbium, and hence called by him *ytterbium*. In separating the earths of this mineral, he heated the mixed nitrates until they became pasty. On treating the mass with boiling water, an insoluble residue remained, in which the erbium was concentrated. By repeating the operation many times, a pure rose colored earth was obtained, which was erbia, the atomic weight rising to that of erbium, 128 or 129. On continuing the operation, he was surprised to find that the increase of the rose color, of the absorption bands and of the atomic weight which at first kept together, finally separated; the atomic weight slowly increasing, while the rose color and the bands diminished; so that the last product was perfectly white, its salts were colorless and its spectrum showed no absorption bands. The purest product gave an atomic weight of 130·8; hence 131 may be provisionally adopted. Ytterbium nitrate is decomposed by heat without coloration, the oxide is much less attackable by acids than the other oxides of this group, the sulphate is isomorphous with those of yttrium and erbium, redissolves easily and completely in a saturated solution of potassium sulphate, no precipitate being formed on boiling, the chloride in neutral solution is not precipitated by boiling with sodium hyposulphite, the formate dissolves in less than its weight of water and resembles the same salt of yttrium and erbium, and loses its crystal water at 100°. These properties distinguish it from thorium, the only element of this kind known

* This Journal, xvi, 384, November, 1878.

'hose atomic weight is high. Its symbol is Yb.—*C. R.*, lxxxvii, 78, Oct., 1878. G. F. B.

5. *On a Simple Vapor density Method.*—VICTOR MEYER has roposed a very simple mode of approximate vapor density de- ermination, dependent on the measurement of the air expelled y the vapor. He uses an elongated cylinder of about 100 c. c. apacity, closed at bottom and having a tube of some length ttached at top, in the side of which is a lateral tube by which ie air may be conducted to a graduated tube. The vertical tube i to be closed with a cork. To use it, the apparatus is placed in ie vapor of a liquid of sufficiently high boiling point, or even in metallic bath. After the temperature has become constant and ie air in the cylinder has finished expanding, the end of the iteral delivery tube is placed beneath a graduated tube full of 'ater, the cork is removed, the substance dropped through the ube into the cylinder, and the vessel closed. The substance olatilizes at once and expels its own volume of air from the ves- el, which is collected and measured in the graduated tube. Neither the capacity of the vessel nor the temperature of the ath are needed in the calculation. This requires only the reight of the substance, the temperature of the room, the height of the barometer and the volume of air expelled. The results re close enough for molecular weight determinations, as the fig- ures given show.—*Ber. Berl. Chem. Ges.*, xi, 1867, Nov., 1878. G. F. B.

6. *On the Separation of Zinc from Nickel.*—BEILSTEIN has proposed the use of citric acid in the analytical separation of nickel from zinc, having found that in presence of citric acid and citrates, zinc is completely precipitated by hydrogen sulphide, while all the nickel remains in the solution. The solution contain- ing the two metals, which must be quite dilute and contain them as nitrates or sulphates, is treated with ammonia to alkaline reac- tion and is then acidulated with pure citric acid. Into the perfectly cold solution, hydrogen sulphide is passed for five or ten minutes, or until it strongly smells of the gas, allowed to stand for an half hour, repeating the operation until the odor no longer disappears on standing. The precipitated zinc sulphide is allowed to stand twenty-four hours in the cold, is filtered off and weighed. The filtrate is evaporated to a small bulk and from it the nickel is pre- cipitated electrolytically. The separation is complete as is shown by the examples given.—*Ber. Berl. Chem. Ges.*, xi, 1715, Oct., 1878. G. F. B.

7. *On the formation of Purpureo-chromium salts.*—JÖRGENSEN has succeeded, by the oxidation of an ammoniacal solution of chromous chloride $CrCl_2$, in producing a chloride of chloro-pur- pureochromium, the original sky-blue fluid becoming of a beau- tiful red color. The formula of the chloride of the new compound is $Cl_2[Cr_2(NH_3)_{10}]Cl_4$, analogous to purpureocobalt chloride, which it resembles in solubility. From aqueous solutions it is com- pletely precipitated by hydrochloric acid. Nitric acid produces

in the aqueous solution a magnificent carmine red chloro-nitrate of the composition $Cl_2[Cr_2(NH_3)_{10}](NO_3)_4$. In the solutions of this salt the chlorine is not precipitable by silver nitrate. Fluosilicic acid precipitates a silico-fluoride of chloropurpureochromium, which under the microscope appears isomorphous with the corresponding cobalt salt. The author has evidence of the existence of roseo and luteo-chromium.—*J. pr. Ch.*, II, xviii, 248, Nov., 1878.

G. F. B.

8. *On the Atomic weight of Iridium.*—SEUBERT has re-determined with great care the atomic weight of iridium, by igniting in a current of hydrogen, ammonio-iridium chloride and potassio-iridium chloride. The former gave as a mean 193·377; the latter 193·094; the mean of both being 193·220, H being 0·9975; or taking H as 1, the atomic weight of iridium is 192·744.—*Ber. Berl. Chem. Ges.*, xi, 1767, Oct., 1878. G. F. B.

9. *Preliminary Note upon the nature of the Chemical Elements.*—Mr. NORMAN LOCKYER has addressed the following note to the French Academy of Sciences:—"Reasoning from analogies furnished by the behavior of known compounds, I have proved that, independently of calcium, many bodies hitherto considered as elements, are also compound." Mr. Lockyer promises to forward to the Academy the necessary proofs of his assertion."—*Comp. Rend.*, No. 19, p. 673, Nov., 1878. J. T.

10. *Phenomena of Binaural Audition.*—Professor THOMSON, of University College, Bristol, England, thus sums up the results of his investigation upon this subject. "(*a.*) There is an interference in the perception of sound; for two simple tones capable of interfering are still heard to interfere when conducted separately to the two ears. (*b.*) When two simple tones in unison reach the ears in opposite phases, the sensation of the sound is localized at the back of the head. (*c.*) The localization of this acoustic "image" is independent of the pitch of the sound. (*d.*) If the difference of phase is partial, the sensation is localized partly in the ears and partly at the back of the head. (*e.*) If the difference of phase be complete but the intensities unequal, the acoustic "image" instead of being at the middle of the back of the head, is nearer that ear in which the sound is louder. (*f.*) It is possible to discern the difference between two compound tones which differ only in the phase but not in the pitch or intensity of their component partial tones. For when two such compound tones are separately brought to the ears so that the vibrations of any partial tone present reach the ears in opposite phases, that particular partial tone is singled out and localized at the back of the head. (*g.*) When two simple tones are led simply to the ears no differential tone is heard; there is some evidence that summational tones are heard. (*h.*) To binaural audition dissonances are excessively disagreeable and ordinary consonances harsh. (*i.*) Vibrations mechanically conveyed to a point of the parietal or occipital region of the skull on one side, are apparently heard in the ear of the other side of the head."

In his investigation the author made use of a telephone, which is thus seen to occupy a place in acoustic researches.—*Phil. Mag.*, Nov., 1878, p. 383. J. T.

11. *On the Economy and Subdivision of the Electric Light.*—Professor FARMER of the Torpedo Station at Newport, has written a letter to the Salem Observer, calling attention to the fact that the parlor of his house, No. 11 Pearl St., was lighted every evening during the month of July, 1859, by the electric light, and that this electric light was subdivided, too. Since this was nineteen years ago, it was, he thinks, undoubtedly the first private dwelling house ever lighted by electricity; a fact which may be a source of pride to the city of Salem some of these days. As we know of no one better qualified to give an opinion on these important questions, we give the latter portion of Professor Farmer's letter:

"A galvanic battery of some three dozen six-gallon jars was placed in the cellar of the house, and it furnished the electric current which was conveyed by suitable conducting wires to the mantle-piece of the parlor, where were located two electric lamps, on each end of the mantle-piece—(I should not wonder if the screw holes were there at this day). Either lamp could be lighted at pleasure, or both at once, by simply turning a little button to the right for a light, to the left for a dark. No matches, no danger, no care to the household, nor to anyone except to the man who attended to the battery.

This light was noticed as being soft, mild, agreeable to the eye, and more delightful to read or sew by than any light ever seen before. Its use was discontinued, at that time, for the simple reason that the acids and zinc consumed in the battery made the light cost about four times as much as an equivalent amount of gas-light. Now that we can have cheap electricity from the dynamo-electric machine, we may soon expect better things of it.

In the year 1875 I subdivided an electric current into forty-two different branches, putting a light into each branch. All these lamps were supplied with electricity from one machine, which did not weigh more than eight hundred pounds, and which was driven by a small steam engine.

Now a word as to the cost of electric light as compared with light from gas. Perhaps on the average, one pound of illuminating gas will, if burned in an hour in five different burners, give fifteen candle lights to each burner, or seventy-five candle lights in all. One pound of illuminating gas possesses a sufficient store of energy to enable it to give out by combustion, from eighteen thousand to twenty-one thousand units of heat, or the equivalent of from thirteen to sixteen million foot-pounds of work. This, if burned in an hour, would average from two hundred to two hundred and sixty thousand units of work per minute, or say from three thousand to thirty-five hundred foot-pounds per minute per candle light.

Now a very large electric light, say ten thousand candles,

does not demand or consume more than fifteen or twenty foot-pounds of energy per minute per candle light, and even so small an electric light as twenty or thirty candles need not consume so much as two hundred foot pounds per minute per candle light. So it might not seem very extravagant to expect that one pound of gas per hour could be burned in a suitable furnace under a proper boiler, and steam be taken from this boiler to a steam engine, and this engine drive a magnetic electric machine which should supply electricity to five electric lamps that would shed forth more light than could be given by five of the best gas lamps known, each lamp consuming at the rate of one-fifth of a pound of the best illuminating gas per hour; and this would not be half so absurd an expectation as it would have been three years ago, for some visionary to have predicted that the talking Phonograph would succeed in embalming speech."

U. S. Naval Torpedo Station, Newport, R. I., Oct. 30, 1878.

II. GEOLOGY AND MINERALOGY.

1. *Report of the Geological Survey of the Fortieth Parallel*, CLARENCE KING, Geologist in charge: Volume I, *Systematic Geology*, by CLARENCE KING. 804 pp. 4to, with 28 plates and 12 analytical geological maps, and accompanied by a geological and topographical atlas. Submitted to the Chief of Engineers, and published by order of the Secretary of War, under authority of Congress.—The field work of the Geological Survey of the 40th Parallel commenced in 1867, and continued until 1873; the no less important labor of studying the material collected, arranging for publication facts observed, and drawing conclusions from them has only been finally concluded during the past year. The study of the geology of the region explored was carried on by Mr. King and his associates, Mr. Arnold Hague and Mr. S. F. Emmons, of the mining districts by Mr. J. D. Hague, and of the botany by Mr. S. Watson; the topography was in the hands of Mr. J. T. Gardner.

The area covered by their explorations forms a belt of country 100 miles wide, from north to south, and extending from the meridian 104° west in a direction a little south of west as far as longitude 120° west; it partly encloses the 40th Parallel, but near the eastern extremity deviates a little to the north of the line. Of this tract of country Mr. King says, in the opening chapter of his volume: "It has rarely fallen to the lot of one set of observers to become intimate with so wide a range of horizons and products. Embracing within its area a pretty full exposure of the earth's crust from nearly the greatest known depths up through a section of 125,000 feet, taking in all the broader divisions of geological time—a section which has been subjected to a great sequence of mechanical violence, and can hardly fail to become classic for its display of the products of eruption—this Exploration has actually covered an epitome of geological history." It should be added that, at the time when Mr. King's party took the field, the

gion was one which was unmapped, unstudied, and of which ›thing but a few isolated details was known. The value of the ork accomplished can be best appreciated when the difficulties hich had to be overcome are understood.

The several volumes of the Survey, in their order of publication, e as follows:—Vol. iii, Mining Industry, by James D. Hague, ith geological contributions by Clarence King, 1870. Vol. v, otany, by Sereno Watson. Vol. vi, Microscopical Petrography, r Ferdinand Zirkel, 1876. Vol. ii, Descriptive Geology, by rnold Hague and S. F. Emmons, 1877. Vol. iv, Part I, Palæon-logy, by F. B. Meek; Part II, Palæontology, by James Hall and . P. Whitfield; Part III, Ornithology, by Robert Ridgway, 1877. eological Atlas, containing ten double maps, 1878. Vol. i, Sys-matic Geology, by Clarence King, 1878.

The concluding volume in the series, now published, presents a 'stematic statement of the geological facts taken in order of ›ological time, collected by Mr. King and his associates, Messrs. ague and Emmons, with the conclusions which he himself has rawn from them. The detailed presentation of these facts, in their eographical order, had already been given in volume ii, on De-:riptive Geology (noticed in this Journal, vol. xvi, p. 234). In ›us bringing together in a single volume the grand results of his urvey, Mr. King has given much greater and more permanent alue to the labors of himself and his associates. The clear and ystematic manner in which both the facts observed and the the-›ries advanced are presented, is worthy of high praise; Mr. King's ;raceful pen never showed itself to better advantage. It is per-›aps unnecessary to add that the appearance of the volume is all that could be desired; the many plates are executed in the best manner. An especially valuable feature of the volume is to be found in the series of geological charts, one of which accompanies the description of each formation and gives the distribution of the rocks belonging to it. In another number we expect to cite some pages from the work, which will show some of the more important conclusions reached.

2. *Tenth Annual Report of the United States Geological and Geographical Survey of the Territories.* Being a Report of Progress of the Exploration for the year 1876, by F. V. Hayden, U. S. Geologist; 546 pp. 8vo, with 74 plates and 3 large maps. Washington, 1878.—This large and valuable volume contains, besides the opening letter of the geologist in charge, the following reports: Part I, by C. A. White, On the geology of a portion of Northwestern Colorado; by F. M. Endlich, on the geology of the White River District, on the Mineralogy of Colorado, and on the Erupted rocks of Colorado; by A. C. Peale, on the geology of the Grand River District; by W. H. Holmes, on the geology of the Sierra Abajo and West San Miguel Mountains; Part II, Topographical reports by A. D. Wilson, Henry Gannett, G. B. Chittenden and G. R. Bechler; Part III, On Archæology and Ethnology by W. M. Holmes, W. H. Jackson and W. J. Hoffman; and

Part IV, On Cretaceous and Tertiary plants by Leo Lesquereux; On injurious Insects by A. S. Packard, Jr. The Archæological reports contain detailed descriptions of the ancient ruins in Southwestern Colorado and adjacent territories. A large number of excellent plates, illustrating both the distribution and character of the cliff houses, and also the remains of pottery and other implements found in connection with them, besides admirable plans, sketches, sections, increase the value of the reports. The Report contains also two beautiful colored geological maps of Colorado, and a third map giving the drainage of the Territory.

3. *Bulletin of the United States Geological Survey of the Territories;* F. V. Hayden, Geologist-in-charge. Vol. iv, No. 4.—This number of the Bulletin contains papers by S. H. Scudder on the fossil Insects of the Green River shales; by D. S. Jordan on Fishes of Dakota and Montana, collected by Dr. Coues; by J. W. Chickering on Plants of Dakota and Montana, collected by Dr. Coues; by F. M. Endlich on Erosion in Colorado; by C. A. White on the Laramie Group; by J. A. Allen on the American Sciuri or arboreal squirrels. An index to volume iv closes the number.

4. *On the Origin of Stylolites;* by Edward T. Nelson. (Communicated.)—During the past summer while spending a few days at a Post of the Hudson's Bay Company, called Red Rock, situated three miles above the mouth of Nipegon River, Lake Superior, I had opportunity for observing the formation of stylolites on a grand scale. The left bank of the river, just below Nipegon Rapids, is, perhaps, fifty feet in height, and is composed of strata of fine sand, with thin intercalated layers of clay. Owing to the protecting influence of the clay the face of the bank presents a series of steps. For a distance of some hundreds of feet, and vertically from top to bottom, the surface, at the time of our visit, was covered with stylolitic columns. In each case these columns reached from one stratum of clay to the next below, and hence varied in height from two inches to as many feet. During the first afternoon it was raining gently. The water falling over the edges of the exposed layers of clay washed the *sand vertically from beneath.* In this way each stratum of sand presented the same projections and crevices as its covering layer of clay. As soon as the sun came out the exposed edges of the stylolites became covered by a very thin pellicle of the clay and were thus preserved. Wishing to learn whether these columns became sufficiently hard to stand pressure, I removed, very gently, portions of the talus of sand from the base of the hill and found within perfectly preserved columns. The inner face of the talus was, of course, the exact obverse of the stylolites.

Ohio Wesleyan University, Oct. 22d, 1878.

5. *Bowlders in Coal.*—During a recent geological excursion with the Senior class of Denison University, I found at New Straitsville, Perry County, Ohio, a bowlder of hard gritty sandstone, ten inches in diameter, in a seam of coal. It was covered to the depth of one foot and rested upon seven feet of coal, the

seam being the Nelsonville, or "Great Vein," which lies two to three hundred feet above the base of the Coal-measures. The roof is a bluish gray shale containing the usual Carboniferous fossils.

It seems improbable that this bowlder was brought into the ancient marsh when the material for the lower seven feet of coal had accumulated, and was then covered with the several feet of vegetable matter which are now compressed into the upper foot of coal. The Nelsonville seam has a wide distribution in southeastern Ohio and Kentucky. It is the most reliable and persistent coal of the lower productive measures. This implies that the marsh in which it accumulated was very widespread, and that it long retained its character as an area of sluggishly moving, or stagnant waters, so choked with rank vegetation that drift-wood or floating ice (if any such thing existed in that age) would have no chance of being carried far over its surface. But it afterward sank beneath a shallow sea, muddy with the sediment which is now hardened into the roof shales. Sometimes during this submergence the bowlder was dropped upon the still soft and yielding mass of vegetation and sank into it to a considerable depth. By what agency it was transported from the shores of that ancient sea to its present resting place is uncertain. Two similar cases are on record, and two eminent Ohio geologists have speculated upon the causes of the phenomena. Professor E. B. Andrews (Report of Progress, 1870, p. 78) mentions a large quartzite bowlder in this same Nelsonville seam at Zaleski, Vinton County, and attributes its transportation to floating ice. Professor J. S. Newberry (Ohio Reports, vol. ii, p. 174) mentions one of talcose slate found by him in Coal No. 2, in Mahoning County, and opines that it was brought there by being "entangled in the roots of trees, and thus floated and dropped." Whatever may have been the buoyant material we can readily conceive that, once upborne upon the water, these bowlders might easily have been driven by winds, or carried by currents, to where we now find them, and penetrated the material of the coal by virtue of their weight and compactness, while the mud carried by the same waters spread over the coal a sheet of fine sediment without mingling with it.

Granville, Nov. 19th, 1878. L. E. HICKS.

6. *Ashburner on Oil-well Records in McKean and Elk Counties, Pennsylvania.*—In a citation from this memoir on page 393 of the preceding volume, the sentence reading "We are sure that the rocks maintain a constant thickness between these two points," should read "We are not sure," etc.

III. Botany and Zoology.

1. *Flora Brasiliensis.*—The publication has made great progress during the year 1878. In February appeared fascicles 75 and 76; in June fasc. 77, in August fasc. 78. The subjects, in order of publication, are:

Hippocrateaceæ, by Dr. J. Peyritsch, Curator of the Vienna

herbarium. While retaining the order, it is remarked that one isomerous genus makes a transition to *Celastraceæ*.

Meliaceæ, by Casimir DeCandolle, who has recently published a monograph of the whole order in the series which is to continue and supplement the Prodromus. This order is not very largely developed in Brazil.

Hederaceæ, by E. Marchal, Professor of Botany at Brussels. The Brazilian species belong to four genera, which are well illustrated.

Lemnaceæ, by Professor Hegelmaier of Tübingen, the monographer of the order. The three genera, *Wolffia*, *Lemna*, and *Spirodela* are well illustrated in a single plate, and the anatomy and morphology are fully expounded.

Araceæ, by Professor Engler, late of Munich, now translated to Kiel. There are about ninety Brazilian species out of 738 known to the monographer, who arranges them under ten sub-orders, and the larger sub-orders have two, three, and five tribes. But among the sub-orders are *Pistiaceæ* and *Lemnaceæ*. The whole is evidently worked out conscientiously, and is admirably illustrated by fifty-one plates, which abound in analyses. One of them is a photograph of magnified stem-sections.

Rafflesiaceæ, by Count Solms-Laubach, Professor at Strassburg. In Brazil are two known species of *Apodanthes* and four of *Pilostyles*. The single plate of illustrations is excellent.

Nymphæaceæ, by Professor Caspary of Kœnigsberg, are amply and well illustrated. Three folio plates are given to *Nymphæa ampla* and its varieties, six to other species, and two to *Cabomba* and some details of *Victoria*. Three typical species of *Cabomba* are described, and the character of *C. Caroliniana*, with full descriptive details is given in a foot-note. The *Nelumbium* of South America proves to be *N. luteum;* and the Japanese *N. nuciferum* is thought to be hardly different. Three species of *Victoria* are indicated, but with doubts as to their distinctness. One of the ten tropical American species of *Nymphæa*, viz: *N. ampla*, well marked by having the carpels separate through the center and cohering only dorsally, reaches Texas.

Cucurbitaceæ are elaborated, with much detail, by A. Cogniaux, a Belgian botanist. Introductions included, there are twenty-nine Brazilian genera, and one hundred and eleven species, arranged under the series proposed in Bentham and Hooker's Genera Plantarum. Eichler is followed in placing the order next to Campanulaceæ, a reversion to the ideas of Bernhard Jussieu and Adanson. *Cucurbita Pepo* is thought to be of Asiatic origin; perhaps rightly. But our Indians had it, along with *Nicotiana rustica*, which is certainly an old-world species. *Echinocystis* is still mixed up with *Megarrhiza*—a wholly distinct genus,—and with two Brazilian plants which, we venture to say, are not congeners of the true *Echinocystis*. The order is here illustrated by thirty-eight plates. A. G.

2. HEER: *Flora Fossilis Arctica.* Tome v. 1878.—This new volume, like most of its predecessors, is composed of separate

irs, some here first printed, some extra issues from academic ctions and the like. The first paper, on the Miocene Flora innell's Land (with nine plates and a map and sketch), is ally printed at Zurich. The two following papers, on an and Eastern Asian fossil plants, are from the Memoirs e Imperial Academy of St. Petersburg; the remaining two om the Memoirs of the Royal Swedish Society at Stockholm, lustrate the Miocene flora of Sachalin and the *Cordaites* of Zembla. There are numerous figures. The first named most interests us, by the announcement of the discovery of mains of a Miocene Spruce of the *Tsuga* group, i. e., allied r Hemlock Spruce; also of the veritable Silver Fir of e! A. G.

Epping Forest, and how best to deal with it, is an article in ortnightly Review for November last, and separately issued, LFRED R. WALLACE. It urges—now that the ground which ncient forest in the neighborhood of London covered, and rt still covers, is consecrated by act of Parliament for the tion and enjoyment of the public forever—that the large portions shall be replanted in a way that may exemplify reproduce, separately, the several kinds of forest of the ern hemisphere. Even some forests of the temperate por- of the southern hemisphere—of New Zealand, for instance, be hopefully planted. The complete feasibility and the interest of this project are well set forth, and are fortified e authority of this Journal. Mr. Wallace, who is exceed- well qualified to judge, adopts fully the theoretical views are maintained in recent articles of this Journal, as to the of the poverty of Europe in indigenous trees, in comparison North America and Eastern Asia, and her own Tertiary ; and would reclaim for England the trees and shrubs of she was long ago deprived by icy fate. A. G.

Die Algenflora des Weissen Meeres; by Dr. CRISTOPH GOBI. . from Mem. Imp. Acad. Sciences, St. Petersburg, vol. xxvi,).—The above named paper is the first detailed account of lgæ of the White Sea. The species are principally those throughout the Arctic Ocean; but Dr. Gobi remarks that egetation of the southern part of the White Sea has a more ern character than that of the northern part; which is ined by the statement that many forms of Western Europe make their way to the northern part do not extend to the ern part of the White Sea. Dr. Gobi unites a considerable er of species considered by Agardh and others to be dis- even regarding *Rhodomela lycopodioides* as a form of *R. sca*, and *Polysiphonia arctica* as a variety of *P. variegata*. *lophyllis veprecula* Ag. is referred to *R. dichotoma* Lepechin. paper contains valuable references to the species of Ruprecht St. Petersburg Academy's herbarium. W. G. F.

North American Fungi: Fungi Americani, Centuries I II; by H. W. RAVENEL and M. C. COOKE. *North Ameri-*

can Fungi; by J. B. Ellis.—Since the *Fungi Caroliniani Exsiccati* by Ravenel, the last volume of which appeared in 1860, a large number of new species of fungi have been described by writers in Europe and this country, only a small number of which have ever been issued in any of the series of Exsiccati, which have in recent years become uncomfortably numerous. Several American species, to be sure, have been published in Thümen's Mycotheca Universalis, but, comparatively speaking, the number is small. From the nature of the plants themselves, and the fact that many mycologists remote from one another are constantly describing new species, many of which are founded on very minute distinctions, it is very much to be desired that an authentic series of American fungi should be in the hands of leading mycologists of Europe and this country. For this reason, if for no other, we welcome the fasciculi just issued by Messrs. Ravenel and Cooke, and that by Ellis.

The first series named includes specimens collected in Georgia and Florida by Mr. H. W. Ravenel, whose *Fungi Caroliniani* have made his name familiar to all students of fungi. The determination of the species and their arrangement has been undertaken by the well-known British mycologist, Mr. M. C. Cooke. The series will include about four hundred species, published in centuries, at the rate of twenty-one shillings each. American orders may be addressed to H. W. Ravenel, Aiken, S. C. The series includes a number of new species, which are being described in the current numbers of Grevillea.

The second of the series named is issued by Mr. J. B. Ellis, of Newfield, N. J.; and the first century contains species collected by him in the vicinity of Newfield, including a number of the new species described by Cooke and Ellis in Grevillea, and by Ellis and Von Thümen in the Torrey Bulletin. Mr. Ellis intends in the succeeding centuries of his work to include species from all parts of the United States, and has secured the aid of several mycologists in different parts of the country, who will furnish specimens and, at times, descriptions of species. So far as is practicable, an effort will be made to place in the same fasciculus only plants belonging to the same order, so that the student will find a large suite of related species placed near together for comparison. Century II will contain principally *Ascomycetes*, by Mr. Ellis, and Century III, *Uredinei*, by W. G. Farlow. The series will include common as well as rare forms, and it is to be hoped that it may become for this country what Rabenhorst's *Fungi Europæi* is for Europe. Each fasciculus is neatly bound in a form similar to that of Rabenhorst's Fungi, and is sold at the rate of $7.00. Orders can be sent to J. B. Ellis, Newfield, N. J.

W. G. F.

6. *The Early Types of Insects;* by Samuel H. Scudder. (Abstract of a paper read before the National Academy of Sciences, November 5, 1878).—The earliest remains of insects from the Paleozoic rocks were announced in 1835 by Audouin and

ɔrda. Since then many authors, especially Germar and Golden-
ɪrg, have added to our knowledge, until now perhaps one hun-
ed species are known. Yet insect remains in the older strata
ay still be looked upon as the greatest rarities, and by far the
rger part of them are known to us only by their wings.

It is of course of prime importance that we should understand
e relative subordination of the larger groups in insects before
vestigating their order of succession in time; for one of the
incipal difficulties in attempting to harmonize their structural
ıd geological relations has been in the erroneous views which
ıve been maintained of the relative rank of the suborders of
exapods and of their division into series. The author con-
nded for the accuracy of Packard's classification, which sepa-
ted them into Metabola and Heterometabola, the former includ-
g the Hymenoptera, Lepidoptera and Diptera; the latter the
oleoptera, Hemiptera, Orthoptera and Neuroptera, the arrange-
ent being in a descending order. He was also inclined to agree
ith Dohrn in his estimate of the ordinal value of the peculiar com-
nation of characteristics in Eugereon and other early insects and
accept, but with somewhat different limits, the term Palæodicty-
ɔtera applied to this group by Goldenberg. He discussed the
mes of appearance and relative abundance of the different subor-
ɛrs of Hexapods and concluded with the following recapitulation:
(1.) With the exception of the few wings of Hexapods known
om the Devonian, the three orders of insects—Hexapods,
rachnids and Myriapods—appeared simultaneously in Carbonif-
ous strata. (2.) All Carboniferous and Devonian insects are
eterometabola, the Metabola making their first appearance in
urassic strata. (3.) Many synthetic or comprehensive types
cisted in Paleozoic times, combining the characters either of all
ıe Heterometabola; of Orthoptera and Neuroptera; or of Neu-
ɔptera proper and Pseudoneuroptera. (4.) The Devonian insects
ther belong to comprehensive types related to the two lower
ıborders only, or are low Pseudoneuroptera; and were undoubt-
lly aquatic in early life. (5.) The lower suborders of Heterome-
ıbola (Orthoptera and Neuroptera) were much more abundant
ı Paleozoic times than the higher (Coleoptera and Hemiptera).
ɔ.) Nearly all the Paleozoic Orthoptera belonged to the lower,
onsaltatorial families, and are almost exclusively cockroaches.
ʼ.) The Neuroptera proper were at that time much rarer than
ıe lower Pseudoneuroptera. (8.) All the earlier types were
ıerefore of inferior organization. (9.) The general type of wing
ːructure in insects has remained unaltered from the earliest time.
10.) With the exception of two species of Coleoptera, the front
nd hind wings of Paleozoic insects were similar and membran-
us. (11.) The series of facts presented to us by the progress of
ˌeological research leads to the conviction of the probable exist-
nce and possible discovery, in the Devonian and even in the
ilurian formation, of winged insects, still more generalized in
tructure than any yet detected in the Paleozoic rocks.

It may further be added that nearly all the earlier insects were large, many of them gigantic in size; and further, that there is a striking similarity between the Carboniferous insect fauna of Europe and North America.

IV. ASTRONOMY.

1. *Constants of the Terrestrial Spheroid.*—In the Astron. Nach., No. 2,228, Professor LISTING gives the following results of his determination of the constants of the earth's figure:

$a = 6{,}377{,}377^{m.}$	$l_0 = 990{\cdot}9948^{mm.}$
$b = 6{,}355{,}270^{m.}$	$l^* = 993{\cdot}5721^{mm.}$
$R = 6{,}377{,}000^{m.}$	$l' = 996{\cdot}1495^{mm.}$
$Q_0 = 10{,}017{,}560^{m.}$	$g_0 = 9{\cdot}780728^{m.}$
$Q = 10{,}000{,}205^{m.}$	$g^* = 9{\cdot}806165^{m.}$
$w = 288{\cdot}4800$	$g' = 9{\cdot}831603^{m.}$

Also in general, $l = 990{\cdot}9948 + 5{\cdot}1547 \sin^2\varphi$,
$g = 9{\cdot}780728 + 0{\cdot}050875 \sin^2\varphi$.

In these expressions $a =$ equatorial rad., $b =$ polar rad., $R = (a^2b)^{\frac{1}{3}}$, or mean radius, $Q_0 =$ equatorial quadrant, $Q =$ meridian quadrant; $w = a \div (a - b)$, or eccentricity of merid. section; l_0, l^* and l' are the lengths of the second's pendulum at the equator, 45°. and pole; g_0, g^* and g', the force of gravity at the equator, 45° and pole; and l and g the corresponding values at any latitude φ. H. A. N.

2. *Failure of Meteors from Biela's Comet in* 1878.—Mr. E. T. SAWYER writes from Cambridge as follows, under date of December 9th:—As far as my observations show, the expected shower of Biela's, proved a complete failure. I carefully looked for meteors conformable to a radiant near γ Andromedæ on the following dates: –November 23, 24, 26, 29, 30, and December 6, 7, and 8. The watches each evening varied from one to four hours in duration, and aggregate about seventeen hours in all. Cloudy weather interfered with watching for a week previous to the 23d, with the exception of a few minutes on the 21st, also on the 25th, 27th, 28th, and December 1st, 2d, 3d, 4th, and 5th. Strong moonlight also prevented the recording of faint meteors after November 29th. During the seventeen hours or more of watching, only three meteors were mapped radiating with any certainty from the deduced center near γ, and these paths prolonged backward meet exactly at R. A. 25° and 42°. Of the three recorded, two were seen during the four hours' watch on the 26th. H. A. N.

3. *Abriss der Praktischen Astronomie*, von Dr. A. SAWITSCH, translated into German from the 2d Russian edition, by Dr. C. F. W. Peters, assistant in the Observatory at Kiel. 848 pp. 8vo, Wilhelm Mauke, Leipzig, 1879.—The first edition of this work, translated from the Russian by Dr. Götze in 1850, has been for near thirty years a standard work for the subjects embraced in it. It is devoted principally to the instruments and processes

mployed in the determination of latitudes and longitudes. It loes not describe the fixed instruments of the observatory, and is herefore more complete in respect to portable ones.

The present edition has been quite fully revised, the changes in nstruments and improvements of methods having required considerable changes in the matter. The Repsold vertical circle and he Ertel universal instrument are especially described. The more ecent methods of utilizing solar eclipses for determination of ongitude replace the older ones. H. A. N.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *International Geological Congress.*—The American Association for the Advancement of Science, at its meeting in Buffalo, August, 1876, appointed an international Committee charged with the organization of an International Geological Congress, to be held in Paris during the Exhibition of 1878. This committee, which consisted of James Hall, W. B. Rogers, J. S. Newberry, J. W. Dawson, T. Sterry Hunt, R. Pumpelly and C. H. Hitchcock, with the addition of T. H. Huxley, Otto Torell, and E. H. Von Baumhauer, then present at Buffalo, chose James Hall for its chairman and T. Sterry Hunt for its secretary. A circular in various languages was at once issued, urging the importance of the proposed congress, for the consideration of which various points were suggested, and recommending the bringing together at the exhibition of collections illustrating the geology of all countries. The assurances of coöperation received by the secretary were such that after a few months, the Geological Society of France took up the matter in connection with the international committee, and naming a local committee, of which Hébert was president and Jannettaz, secretary-general, issued July, 1877, a circular embodying the suggestions of the first committee. This was followed by a second circular, dated February, 1878, fixing the opening of the Congress for the 29th of August. The local committee also prepared a catalogue of all the materials of geological interest in the Exhibition, as well as of all the public and private collections of Paris, which were thrown open to the members of the Congress.

The Congress was opened on the day appointed in the palace of the Trocadero, the Minister of Public Instruction for France, presiding on the occasion, and six daily sessions were held, with Hébert for president, assisted by numerous vice-presidents selected from the various nationalities. The whole number of members enrolled was 328, of which about 250 were present. American geology was represented by James Hall, G. H. Cooke, J. P. Lesley, T. Sterry Hunt, W. P. Blake, E. D. Cope, and T. C. Chamberlin, and by Selwyn from Canada.

The first session was devoted to structural and dynamical geology and included among others, papers by Daubrée and Alphonse Favre, both giving results of experiments relative to the origin of

fractures and foldings of the earth's crust. These were followed by Lory on the structure of the Alps, by de Chancourtois on the coördination of the lines and veins, and by De Lapparent on the foldings of the Chalk as disclosed by the examinations for the tunnel beneath the streets of Dover.

In the second session, James Hall discussed the history of the rise and progress of the nomenclature of the Paleozoic rocks in North America, and of the various geological maps, while Renevier, de Chancourtois and Huguenin submitted their plans for the use of colors and signs in mapping. Stephanesco and Rutot discussed the value of geological subdivisions and the bases of a uniform geological nomenclature for all countries, while Vilanova set forth his plan of a general dictionary of geology.

In the third session, Sterry Hunt presented a memoir on the upper and lower limits of the Cambrian series, and was followed by Barrande on the same subject. Von Mœller then discussed the constitution of the Carboniferous series in different regions of Europe, and its relations to Devonian and Permian, and was succeeded by Lesley on the same questions as presented in Pennsylvania, and by Vélain on the relations of the Trias and Lias in France.

In the fourth session, Cope discussed the relations of the horizons of fossil verebrates in Europe and America, and was followed by Albert Gaudry and by Matheson on the same subject. De Mortillet presented his views on the Quaternary formations, and Alph. Favre discussed the hypothesis of former glacial periods. Van der Broeck and Buviguier discussed the agency of meteoric phenomena in the alterations of rocks, and W. P. Blake presented and described a geological map of the United States of America. The origin of volcanoes was then considered by Virlet d'Aoust, after which the local admixtures of organic remains of different horizons, giving rise to what have been called colonies is alike in Jurassic and Devonian strata, was discussed by Choffat, Renevier and Gosselet.

In the fifth session, DesCloizeaux and Michel Lévy discussed various questions as to the feldspars in crystalline rocks, their chemical composition and microscopic character, and were followed by Sterry Hunt, on the constitution of the plagioclase feldspar, while Jannetaz treated of the geological importance of the propagation of heat in rocks, considered with reference to their structure and their origin. Sterry Hunt then gave a description of the great groups of crystalline stratified rocks found in North America, including Laurentain, Norian, Huronian, Mount Alban and Taconian, and compared them with similar groups in Europe. He was followed by Selwyn on the same subject. Szabo discussed the eruptive Tertiary rocks of Hungary, examining the question whether mineral composition can serve to show the ages of such rocks. Velaine contributed an account of the trachytes of the Reunion island and Ribeiro and of the Tertiary basalts of Portugal.

In the sixth and last session of the Congress, on the 4th of September, a communication by Bourjot was presented on the supposed eruptive limestones of Algeria, and one on some glacial phenomena of the Great Lakes district of North America, by Chamberlin, while Fuchs stated the views of several members of the Congress on the system of coloring geological maps. The President then announced the decision of the Council that the acts of the Congress are to be published in a volume under the direction of the secretaries, the cost being generously defrayed by the national government. A second International Geological Congress will be held at Bologna in Italy, in October, 1881, under the honorary presidence of Sella, president of the Accademia dei Lincei of Rome, and a local committee of ten Italian geologists has been named, charged with the organization of the Congress, of whom Prof. Capellini of Bologna will probably act as secretary. The government of the King of Italy, through the ambassador at Paris, at once promised its high patronage to the future Congress, and the municipality of Bologna sent a message of welcome.

The work of the next congress is referred to two international committees; the first of which will be charged with the unifications "des figures géologiques," that is to say, of all colors or signs employed on geological maps and plans. The second is charged with the unification of geological nomenclature, under which will be considered all questions relating to classification, as well as the value and significance of mineralogical, lithological and paleontological characters embracing the most important problems in geology. For these two international committees one member is named for each country, whose duty it will be to organize therein local committees, and to make known the composition of these as soon as possible both to the Secretary-General of the late Congress, and to the local committee of the future one. Reports by these several committees are to be sent before the first of January, 1881, to the Italian local committee of organization, who will cause them to be printed and distributed before the meeting of the Congress.

The members of the international committee on maps are as follows: United States, Lesley; Canada, Selwyn; Great Britian, Ramsay; France, de Chancourtois; Belgium, Dupont; Switzerland, Renevier; Italy, Géordano; Spain and Portugal, Ribeiro; Hungary, von Hautken; Russia, von Mœller; Scandinavia, Torell.

The international committee on nomenclature and classification is thus composed: United States, James Hall; Canada, T. Sterry Hunt; Great Britain, T. McKenna Hughes; France, Hébert; Belgium, Dewalque; Germany, Ferd. Römer; Switzerland, Alph. Favre; Italy, Capellini; Spain and Portugal, Vilanova; Hungary, Szabo; Roumania, Stephanesco; Russia, Inostranzeff; Scandinavia, Lundgren; Australia, Liversidge.

In addition to the above a local committee was named in France to discuss for the next Congress, the rules to be observed

in the nomenclature of species, consisting, for paleontology, of Cotteau, Douvillé, Gaudry, Pomel, Gosselet and de Saporta, and for mineralogy and lithology, of DesCloizeaux and Jannettaz. The report of the committee of the American Association in 1876, on biological nomenclature, presented by Cope to the Congress, was referred to the above-named committee. The general language of the proceedings was of course, French, but communications made in English were interpreted by MM. Barrois and T. Sterry Hunt, and will be duly translated for the published acts of the Congress.

T. S. H.

2. *National Academy of Sciences.*—At the session of the National Academy of Sciences in New York City, November 5–8, 1878, the following papers were presented.

HENRY DRAPER.—The Solar Eclipse of July 29, 1878.

S. H. SCUDDER.—The early types of insects.

C. S. PEIRCE.—The acceleration of gravity at initial stations.

W. P. TROWBRIDGE.—The inapplicability of the old theory of the turbine water-wheel to the newer constructions instituted by Boyden & Francis.

A. A. AGASSIZ.—(1.) The embryology of the gar-pike.—(2.) Arrangement of a zoological marine laboratory at Newport, R. I.

ELIAS LOOMIS.—Contributions to Meteorology: the storms of the Atlantic Ocean.

H. L. ABBOTT.—(1.) Biographical memoir of Prof. D. H. Mahan.—(2.) Value of photography in the study of instantaneous phenomena, illustrated by photographs of torpedo explosions.

BENJAMIN ALVORD.—Continuation of paper presented at the April meeting, On the intersection of circles and the intersection of spheres.

STEPHEN ALEXANDER.—(1.) On the eleventh axiom of Euclid and a proposed demonstration of the same.—(2.) Recapitulation of some of the author's views on the origin of the forms and present state of many clusters of stars and of several nebulæ, the source of solar heat, and drift of the stars.—(3.) Brief notice of the total solar eclipse of January 11, 1880.—(4.) On certain modifications of the Schehallien experiments, and of the Cavendish experiment.

GEORGE DAVIDSON.—Instruments of precision at the Paris Exposition.

J. S. NEWBERRY.—(1.) On some remains of new fossil fishes and their relation to living forms.—(2.) On some mooted points in American Geology.

O. N. ROOD.—(1.) On a quantitative analysis of white light.—(2.) Note on Henry's theory of color.

E. D. COPE.—On the characters of the Theromorphous Reptilia and Stegocephalous Batrachia.

C. A. YOUNG.—Measures of the diameter of Mercury by a new method, made at the transit of May 6, 1878.

A. HYATT.—Some remarks on an investigation on the laws of heridity undertaken by the Board of Health of Massachusetts.

At the same session on November 6, the Acting President submitted the following *Report of the Committee appointed to consider the Scientific Surveys of the Territories of the United States.* The Report was adopted by the Academy.

The Committee of the National Academy of Sciences, to whom has been referred the consideration of the following requirement of law contained in the Act making appropriations for Sundry Civil expenses of the Government for the fiscal year ending June 30, 1879, and for other purposes, approved June 20, 1878, namely:

"And the National Academy of Sciences is hereby required at their next meeting to take into consideration the methods and

›enses of conducting all surveys of a scientific character under
: War or Interior Department, and the surveys of the Land
ice, and to report to Congress as soon thereafter as may be
icticable a plan for surveying and mapping the Territories of
: United States on such general system as will, in their judg-
:nt, secure the best results at the least possible cost; and also
recommend to Congress a suitable plan for the publication and
tribution of reports, maps, and documents, and other results of
: said surveys,"
bmitted the following report:

The Committee consider that the field of inquiry proposed to
: Academy is intended to embrace only such surveys as pertain
the public domain. They have not included in their plan of
ganization surveys and investigations, however scientific in
thod and character, which apply solely to engineering works,
:h as the improvements of rivers, harbors, lakes, etc.; the irri-
tion and drainage of public lands, reclamation of tidal lands,
d protection of alluvial regions from floods. Such surveys and
'estigations, being inseparably connected with engineering
›blems, should, in the judgment of the Committee, be conducted
the Engineer Corps of the Army. Nor do the Committee
:ommend any change in the organization of the Survey of the
eat Lakes, as this is now nearly completed.

The works which seem to fall especially within the limits of
: meaning of the law are: the Geographical Surveys west of the
e hundredth meridian, under the War Department; the United
ites Geographical and Geological Surveys of the Territories
d of the Rocky Mountain region, under the Interior Department;
d the system of Land Surveys, under the supervision of the
nd Office. Besides these, although not enumerated in the law,
e of the most important works now in progress in the interior,
der Act of Congress, is the geodetic work of the Coast and
odetic Survey. Parties of this organization are now conduct-
; a systematic triangulation at several points in the interior,
d any general system, such as is contemplated in the above
v, cannot be wisely devised without taking into account the
ject and organization of this survey. The objects of these
rious surveys are: (1.) An accurate geodetic survey. (2.) A
neral geographical and topographical reconnoissance. (3.) Land
rcelling surveys, on which the Government can part title to
rtions of the public domain. (4.) The economic classification
d valuation of the public domain. To these should be added,
e gradual completion of a general accurate topographical map
the whole Territory of the United States, which shall serve as
›asis for all the scientific and practical needs of the Government
d the people. All this work may be included under two distinct
d separate heads: (1.) Surveys of mensuration. (2.) Surveys
geology, and economic resources of the soil.

We will first consider the present operations of the surveys of
nsuration. Such surveys are now in progress under five dif-

ferent independent organizations: that of the Coast and Geodetic Survey; of the Geographical Surveys west of the one hundredth meridian, under the War Department; of the topographical work of the two surveys under the Interior Department; and of the Land Survey under the Land Office. The final object of all these works of mensuration is the accurate determination of position, and the laying down of lines and points by measurement. There is at present no coördination between these five surveys. Their original determinations of position are independent; their systems of survey discordant; their results show many contradictions, and involve unnecessary expenditure. The geographical reconnoissances carried on under the War and Interior Departments are of little value for the parcelling of land, while the land surveys are of correspondingly slight topographical and geographical value. The operations of the Coast and Geodetic Survey in the interior do not at present include topography and land parcelling. To attain the desirable accuracy, and economy, it is absolutely essential that there should be only one geodetic system, one topographical system, and one land parcelling system, all conducted under the same head. It is evident that both topographical and land parcelling surveys, to be properly coördinated and sufficiently exact, must be based upon a single rigid geodetic foundation. All these three divisions are departments of measuring; all are based upon accurate determinations of position; and, to be effectively and economically carried out, should be united into one comprehensive system.

After a careful consideration of the facilities at the disposal of the several existing organizations engaged in this work, the Committee believe that the Coast and Geodetic Survey is practically best prepared to execute the entire mensuration system required. Within the public domain, the dominant interest of the United States is centered in the public lands which remain to be surveyed and sold. The administration of these lands, consisting of 1,101,107,183 acres, is necessarily within the Department of the Interior, while the Coast and Geodetic Survey, having been originally inaugurated to meet the wants of commerce, has been hitherto under the Treasury Department. In view of the paramount importance of the public lands, the Committee recommend that the Coast and Geodetic Survey be transferred from the Treasury Department to the Department of the Interior, retaining its original field of operations, and assuming, also, the entire mensuration of the public domain; and that, so modified and extended, it hereafter be known as the United States Coast and Interior Survey. This organization would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnoissance, and land parcelling surveys.

The Superintendent of the Coast and Interior Survey should be appointed by the President, and should report directly to the Secretary of the Interior.

The best interests of the public domain require for the purposes of intelligent administration a thorough knowledge of its geological structure, natural resources, and products. The domain embraces a vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The Committee, therefore, recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the public domain; such survey to be placed under a Director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior.

It should be specially provided that the Director and members of the Geological Survey, charged as they are with the investigation of the natural resources of the public domain, shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations.

Officers of the Army and Navy, when not otherwise employed, might be detailed by the Secretary of War or of the Navy to take part in the operations of either survey.

With the inauguration of the two surveys above defined, the Committee recommend a discontinuance (1) of the present Geographical and Geological Surveys west of the one hundredth meridian, under the War Department, except surveys necessary for military purposes and local internal improvements; (2) of the Geographical and Geological surveys now in progress under the Department of the Interior; and (3) the present Land surveys under the Land Office.

The effect of the above changes will be to maintain within the Interior Department three distinct organizations; (1) the Coast and Interior Survey, whose function will embrace all questions of position and mensuration; (2) the United States Geological Survey, whose function will be the determination of all questions relating to the geological structure and natural resources of the public domain; (3) the Land Office, controlling the disposition and sale of the public lands, including all questions of title and record. With this division should be secured a perfect coördination and coöperation between the three branches. The Land Office should call upon the Coast and Interior Survey for all surveys and measurements required for the sale and disposition of land. The Land Office should also call upon the United States Geological Survey for all information as to the value and classification of lands. The results of all the mensuration surveys, as soon as completed, should be immediately available for the Land Office, and for the Geological Survey, and for other branches of the Government as required. The Geological Survey should be

authorized to execute local topographical surveys for special pu poses, such, for instance, as the subterraneous surveys of minir districts and metallic deposits, etc.

Each of the three organizations, thus defined, should make a annual report of its operations to the Secretary of the Interio The publications of the Land Office should embrace reports of i business operations relating to the disposition and sale of lan together with the necessary maps. The publications of the Coa and Interior Survey, besides the annual report of operation should consist of its geodetic results, geographical, topographic and cadastral maps, coast charts, and such discussions and treatis connected therewith as the Superintendent shall deem of valu The publications of the Geological Survey should consist of a annual report of operations, geological and economic maps illu trating the resources and classification of the land, reports upo general and economical geology in all its branches, with th necessarily connected paleontology.

All collections made by the Coast and Interior, and the Ge logical Surveys, when no longer needed for the investigations i progress, should be transferred to the National Museum.

The Committee recommend that, upon the organization of th United States Coast and Interior Survey and the United Stat Geological Survey, a commission be formed, to consist of th Commissioner of the Land Office, Superintendent of the Coa and Interior Survey, Director of the United States Geologic Survey, the Chief of Engineers of the Army, and three oth persons to be appointed by the President, who shall take in consideration the codification of the present laws relating to th survey and disposition of the public domain; and who shall repo to Congress within one year a standard of classification and val ation of the public land, together with a system of land parcellin survey. The necessity of this commission is evident from the fa that by far the larger part of the public domain lies in the regi where, from geological and climatic causes, the lands are for th most part not valuable for field-culture; and where the system homestead preëmption and sale in accordance with existing la is both impracticable and undesirable.

In regard to publications of the two surveys above defined, th Committee recommend that, besides the number of copies of ea report which Congress may order for its own distribution, thr thousand copies be published, for scientific exchanges by the hea of these surveys, and for sale at the price of publication; that a literary and cartographic material received by the heads of the surveys in exchange be the property of the United States, an form a part of the libraries of the two organizations; that th money resulting from the sale of these publications be cover into the Treasury. The Committee recommend that the annu reports of operations of the two surveys accompany the report the Secretary of the Interior; that the special memoirs and repor of both surveys be issued in uniform quarto series; that the sty

d scale of the cartographic publications be determined by the ad of each organization, so as to express the scientific results in e most effective and economical manner.

All of which is respectfully submitted:

O. C. MARSH, *Vice President, and Acting President.*

JAMES D. DANA, WILLIAM B. ROGERS, J. S. NEWBERRY, W. TROWBRIDGE, SIMON NEWCOMB, ALEX. AGASSIZ, *Members of e Committee.*

[This Report was submitted to Congress at the opening of the esent session and referred to the Committee on Appropriations.]

3. *New York Academy of Sciences.*—Nos. 1 to 4 of the Annals of e New York Academy of Sciences (late Lyceum of Natural History), extending to 128 pages, 8vo, have been published. They conin papers by H. C. Bolton, on the application of organic acids to e examination of minerals; on prehistoric Bronze bells from Japan, r H. S. Munroe; on the variations in Lepidodendron and Sigilria, by H. L. Fairchild; on new species of Birds, by G. N. Lawnce; on the literature of titanium, by E. J. Hallock; on new ssils of the Upper Silurian of Port Jervis, by S. F. Barrett; on w fossil fishes of the Trias, by J. S. Newberry; and they are ustrated by nine plates, six of them by H. L. Fairchild. Dr. ewberry describes *Diplurus longicaudatus*, from Boonton, N. J., d *Ptycholepis Marshii*, from Durham, Conn.

4. *Anales de la Oficina Meteorologica Argentina;* por su irector, B. A. GOULD. Tome I. Clima de Buenos Ayres. 4to,). 523, and 17 plates. Buenos Ayres, 1878.—This first volume Annals of the Meteorological Bureau of the Argentine Republic ntains the first four annual reports of the Director. Following ese are tables exhibiting the peculiarities of the climate of the ty of Buenos Ayres. The materials for this discussion are quite ll records of meteorological observations since 1856, and less mplete ones during scattered years from 1801 to 1856. The incipal part of the computations were made by Dr. Gutermann. e results are very fully exhibited in the plates. In the future lumes of the Annals, Dr. Gould expects to give the observaons made at numerous other points in the Republic, with discusons of them.

5. *Science News.*—A new scientific periodical, under the editorip of Ernest Ingersoll and W. C. Wyckoff, and published fort ghtly by S. E. Cassino, at Salem, Mass. Each number is to ntain at least sixteen pages octavo of reading matter, and its culiar feature is stated to be "the prompt publication of scien fic news." No. 1 (November 1st), contains short articles by r. C. C. Abbott, Professor F. W. Clarke, Dr. Elliott Coues and hers; Nos. 2 and 3 are chiefly occupied with abstracts of papers ad at the recent meeting of the National Academy of Sciences.

6. *An American Geological Railway Guide, giving the geogical formation at every railway station, with notes on interestg places on the routes, and a description of each of the formaons;* by JAMES MACFARLANE, Ph.D. 216 pp. 8vo. New York,

1879. (D. Appleton & Co.)—The scope and general object of this work are well stated in the above title. It occupies a decidedly new place among handbooks of travel and contains a great amount of information in a very condensed form.

7. *Essentials of Chemistry, Inorganic and Organic, for the use of Students in Medicine;* by R. A. WITTHAUS. New York, 1879. 18mo, pp. 257. (William Wood & Co.)—The author has skillfully condensed the "Essentials of Chemistry," for the Medical student, into a vest-pocket catechism, which fulfills well the object for which his little volume has been prepared.

8. *Handbook of Alabama:* A complete index to the State; with a geological map and an Appendix of useful tables, by SAFFOLD BERNEY.—This volume contains a valuable outline of the geology of Alabama, with a geological map of the State, by Eugene A. Smith, Ph.D., State Geologist.

The Amateur's Handbook of practical Information for the Workshop and the Laboratory: containing directions for bronzing, lacquering, polishing metal, etc. 44 pp. 12mo. New York, 1878. (The Industrial Publication Company).

On the Structure of the Stylasteridæ. A family of Hydroid Stony Corals, by H. N. Moseley, F.R.S., late Naturalist on board H. M. S. Challenger. (From the Philosophical Transactions of the Royal Society, Part II, 1878.

Annual Report of the Chief Signal Officer to the Secretary of War for the year 1877. 570 pp. 8vo, with 34 maps and 18 charts. Washington, 1877.

Description of eight new species of Holocystites from the Niagara Group, by S. A. Miller. The new species are: *H. Brauni*, *H. Wetherbyi*, *H. ornatus*, *H. perlongus*, *H. globosus*, *H. pustulosus*, *H. plenus*, *H. elegans;* they are from Jefferson and Ripley counties, Indiana.

Remarks on some Lamellibranchiate Shells of the Hudson River Group by R. P. Whitfield. The new species are: *Cypricardites quadrangularis*, *Cuneamya curta*, *Orthodesma Mickleboroughi*, *Sedgwickia* (?) *lunulata;* locality, Clinton Co., Ohio.

A Handbook of the Electric Telegraph, by A. E. Loring. 98 pp. 12mo. New York, 1878 (Van Nostrand's Science Series).

Statistical Sketch of South Australia, by Josiah Boothby. 86 pp. 8vo. London, 1876. Published by authority of the Government. (Sampson Low, Marston, Searle, & Rivington, London.)

The American Antiquarian: a Quarterly Journal devoted to Early American History, Ethnology, and Archæology. Edited by Rev. Stephen D. Peet, of Unionville, Ohio. Published by Brooks, Schinkel & Co., Cleveland, Ohio.—Vol. i, No. 1, July, August and September, 1878.

A Monograph of the Silurian Forests of the Girvan District in Ayrshire, by H. Alleyne Nicholson and Robert Etheridge, Jr. Fasciculus I. Rhizopoda, Actinozoa, Trilobita. 135 pp. 8vo, with ix plates. Edinburgh and London, 1878. (William Blackwood & Sons.)

Report on the Meteorological Service of the Dominion of Canada, by the Superintendent; to which is appended the Report of the Directors of the Magnetic and other Observatories, for the year ending December 31st, 1877. Ottawa, 1879.

APPENDIX.

:T. IX.—*A new Order of Extinct Reptiles* (SAURANODONTA), *rom the Jurassic Formation of the Rocky Mountains;* by ?rofessor O. C. MARSH.

ГHE absence of the genus *Ichthyosaurus* in the extinct fauna this country has long been a noteworthy feature, for up to : present time no traces of it have been detected, although its nains are especially abundant in Europe. An interesting ɔcimen recently discovered in the Rocky Mountain region ɔsents, in most of its skeleton, the characteristics of that ɿus, but is *without teeth.* The vertebræ, ribs, and other porns of the skeleton preserved, cannot be distinguished from : corresponding parts of *Ichthyosaurus*, and many features the skull show a strong resemblance. The general form of : skull is the same. The great development of the premax.ries; the reduced maxillaries; the huge orbit defended by ·ing of bony plates, are all present, but the jaws appear en:ly edentulous, and destitute even of a dentary groove.

Гhe proportions of this reptile were very similar to those of *thyosaurus.* The skull is about two feet (600^{mm}) in length, l the facial portion especially produced. The orbits are very ge, and the space between them is 140^{mm}. The sclerotic ring ɔomposed of only eight plates. Its diameter at the base is 3^{mm}, and at the apex 58^{mm}. These plates are not arranged a nearly flat ring, as in *Ichthyosaurus*, but form the basal segnt of an elongated cone, as in the eyes of some birds. The ·tebræ are short, and deeply bi-concave. The neural arch is iculated to the centrum. One trunk vertebra measures 85^{mm} width, 38^{mm} in length on the floor of the neural canal, and ^{mm} between the centers of the two rib articular faces of the ne side. The length of the entire animal was about eight or ıe feet. The remains at present known are all in the Museum Yale College.

This reptile may be called *Sauranodon natans*, and the order it represents *Sauranodonta*. This genus bears a similar relation to the Ichthyosaurs that *Pteranodon* does to the true Pterodactyls, and it is interesting to find the two highly specialized forms preserved in the same region.

The geological horizon of the *Sauranodontidæ*, so far as now known, is in the Jurassic, immediately below the Atlantosaurus beds. The accompanying fossils are Ammonites and Belemnites, showing more distinctly marine deposits, which may be called the Sauranodon beds.

Yale College, New Haven, December 27, 1878.

ART. X.—*Principal Characters of American Jurassic Dinosaurs*; by Professor O. C. MARSH. Part II. With eight Plates.

IN a previous article (vol. xvi, p. 411, Nov., 1878), the writer gave a short account of the geological horizon and accompanying fossils of the Jurassic Dinosaurs recently found in the Rocky Mountains; and also stated the more important characters of the gigantic *Sauropoda*, as illustrated mainly by the genus *Morosaurus*. In the present communication, this group is further elucidated by a comparison of the structure in some other American genera, especially *Apatosaurus* and *Atlantosaurus*, to which belong the largest reptiles hitherto discovered. The carnivorous enemies of this group are also briefly described. The pelvis of Dinosaurians, hitherto so little known, is illustrated by new examples, and by the corresponding parts in some recent birds.

Apatosaurus Marsh, 1877.*

The genus *Apatosaurus* may be readily distinguished from *Morosaurus* by the sacrum, which consists of only three vertebræ instead of four (Plates V and VI, figures 1 and 2.) The ischium, also, has its distal end expanded. The scapula, likewise, is quite different, its superior extremity, being without the anterior extension seen in *Morosaurus* (Plate IV.) So far as at present known, the latter character, together with the form of the sacrum, separates it from the allied genus *Atlantosaurus*.

The cervical vertebræ of *Apatosaurus* are strongly opisthocœlian, and of moderate length. (Plate III, figures 1 and 2.) The dorsals have their centra similar, and both have deep cavities in the sides and in the neural arch resembling those in the corresponding vertebræ of *Morosaurus*. The lumbar vertebræ have their articular faces more nearly plane, and the last lumbar

* This Journal, vol. xiv, p. 514.

is expanded transversely. The sacrum is characteristic of the genus, and quite unlike any hitherto known. The type specimen on which the genus was established is well shown in Plate VI, figure 1. It is short and massive, and the three vertebræ which form it are nearly equal in size and general proportions. They are firmly coössified, and their transverse processes are ankylosed to the centra. Those on each side are united distally into a solid mass, which rests on the short ilium. The articular faces of the sacral vertebræ are nearly plane. That of the anterior centrum is a transverse oval in outline, and the posterior face is more nearly round. The centra and their processes are somewhat lightened by cavities, as in the sacra of *Atlantosaurus* and *Morosaurus*. The sacrum of the latter genus, shown in figure 2 of Plate V, is built upon the same general plan, characteristic of the *Sauropoda*, but the transverse processes are less massive, and have a greater vertical elevation. The same sacrum is shown in position in Plate V, figure 1. A striking feature of this sacrum is seen in the large size of the neural canal (*nc*), which, strange to say, is here two or three times the diameter of the brain cavity. This is a most suggestive fact, and without parallel in known vertebrates.

The scapula of *Apatosaurus* is large (Plate IV), and has in its lower portion an anterior projection similar to that in *Morosaurus*.* Above this, the shaft continues about the same width to the upper end, which is comparatively thin. The coracoid is small in proportion to the scapula, and subquadrate in outline, thus differing in form from that of *Morosaurus*. The foramen is large, and near the superior border.

There is at present some difficulty in separating the limb bones and various other parts of the skeleton of *Apatosaurus* from the corresponding portions of *Atlantosaurus*, especially as the type species of each are nearly equal in size, and their remains are found in the same localities. The sacra show the genera to be quite distinct, and the abundant material now in the Yale Museum, when carefully collated, will enable other parts of the structure to be compared. The teeth in all the herbivorous genera of the *Sauropoda* from the Atlantosaurus beds, so far as now known, appear to be very similar, and hence do not afford generic characters.

The type species of the present genus is *Apatosaurus ajax* Marsh, and the known remains indicate a reptile at least fifty feet in length. A much larger species is indicated by various remains from the same locality in Colorado, among which is the huge cervical vertebra represented in Plate III, figures 1 and 2. This species had a short massive neck, and hence may be

* This Journal, vol. xvi, Plate VI.

called *Apatosaurus laticollis.* The size of the entire animal may be judged from this vertebra, which measures over three and a half feet (1·07 M) in width. This would imply a neck at this point not less than five or six feet wide,—a marked contrast to the long and slender neck of *Morosaurus grandis*, a vertebra of which is figured in the same plate for comparison. All the cervical vertebræ of the present species now known are unusually short, and the neural spine is rudimentary or wanting. With the exception of the articular faces of the centra, the resemblance of these cervicals to those in some birds is very striking.

The limb bones at present referred to this species have a general resemblance to those of *Morosaurus*, described by the writer in the previous article. The pelvic bones appear to be more like those of *Atlantosaurus.*

The more important remains of this genus now known were found in the Upper Jurassic of Colorado, by Mr. Arthur Lakes, of the Yale Museum, to whom science is indebted for other interesting discoveries.

Atlantosaurus Marsh, 1877.*

The typical species of this genus is *Atlantosaurus montanus*, and the type specimen on which it was based is represented by the sacrum figured in Plate VI, and various fragmentary remains found with it, and pertaining to the same individual. This sacrum resembles that of *Morosaurus* (Plate V, figure 2), in having four vertebræ, but a comparison of the two shows many differences. The centra of the second and third vertebræ are deeply excavated below on each side, leaving a comparatively narrow keel on the median line. From each opening between the transverse processes, a large cavity extends inward and backward into the centra, greatly lessening the weight of the sacrum. These important characters were mentioned in the original description, (vol. xiv, p. 87, July, 1877), in which the discovery of these large reptiles was first announced.

The ilium in *Atlantosaurus* is comparatively short and massive, but its exact outline has not been fully determined. Its articulations resemble those in the ilium of *Morosaurus*, and in the pelvis represented in Plate VII, figure 2, the outline of this bone is restored from that genus. The pubis is somewhat like that in *Morosaurus*, and its position in the pelvis very similar. It has three distinct articular faces on its proximal end, and, below the ischiadic union, a post pubic projection indicated in the diagram by p'. The distal end is expanded, and rugose for union with its fellow on the median line, as shown in the pelvic

* This Journal, vol. xiv, p. 514. Also p. 87.

arch of *Morosaurus*, in Plate V, figure 1. The ischium is less massive than the pubis, and it is directed downward, backward and inward. The acetabular face is larger than that of the pubis. The shaft of the ischium is not curved as in *Morosaurus*, and the distal end is widely expanded, and unites with its fellow on the median line, in a strong symphysis. The difference in the pelves of the two genera are well shown by a comparison of the figures in Plate VII. The ischium of *Morosaurus* is somewhat more twisted in its distal half than the artist has drawn it in figure 1, where the three bones are represented nearly in the same plane.

The vertebræ referred to *Atlantosaurus* are opisthocœlian in the cervical region, and the caudals preserved resemble those in *Morosaurus*. The limb bones, so far as known, are similar in their more important characters to those in that genus.

The two species now placed in the genus *Atlantosaurus* are the type, *A. montanus*, and *A. immanis*, which contain the largest land animals yet discovered. The latter species may possibly belong to the genus *Apatosaurus*.

The genera of *Sauropoda* above described and figured, viz: *Morosaurus*, *Diplodocus*, *Apatosaurus* and *Atlantosaurus*, show this suborder to be a well marked and natural group, the most generalized of the Dinosaurs. Some other generic names have been given to members of this group by Cope, which I shall review at another time. He still places the horizon of these reptiles in the Cretaceous, although the evidence of their Jurassic age seems now conclusive. In one species which he calls *Camarasaurus supremus* (identical according to Professor Owen with his genus *Chondrosteosaurus* from the English Wealden),† he says, in the sacrum, "the centra are like those of the caudal vertebræ composed of dense bone,"‡ a statement wholly discordant with the known characters of the group. He likewise describes the diplosphenal articulation of the vertebræ as unknown, and states (page 76) that it "has not been observed in any other animals;" whereas it has long been known in *Megalosaurus*, one of the earliest Dinosaurs described, as well as in other genera. The pelvic bones of this species, he says, do not resemble those of *Dinosauria*, when, on the contrary, the pubis he figures is typical in the group. Conclusions based on such work will naturally be received with distrust by anatomists.

Allosauridæ.

In addition to the huge *Sauropoda*, and the small species of the genus *Laosaurus*, described in the previous article, numerous

† Annals and Mag. Nat. Hist., vol. ii, p. 201, Sept., 1878.
‡ Am. Naturalist, vol. xii, p. 77.

remains of carnivorous Dinosaurs occur in the same beds, and indicate the natural enemies which kept in check their herbivorous cotemporaries. These carnivorous forms represent two very distinct families; the *Allosauridæ*, resembling in many respects *Megalosaurus* and its near allies; and the *Nanosauridæ*, a widely different group, which appears to have some affinities with *Compsognathus*. In the present article, the former group is briefly discussed, and both will be more fully described in a future communication.

The genus *Allosaurus* is typical of the family, which also includes *Creosaurus*, and *Labrosaurus*. The first named genus presents some very interesting features in the vertebræ, and pelvic arch. The vertebræ first described are remarkable for the reduction of the centrum by constriction, so that the requisite lightness is secured without cavities in the interior. This is shown in the lumbar vertebra represented in Plate X, figures 3 and 4. The diplosphenal articulation of the zyapophyses, seen in the corresponding vertebræ of *Megalosaurus*, and in some other Dinosaurs, is well marked in these vertebræ.

The sacrum in *Allosaurus* apparently contains four vertebræ only, and these have very short and stout transverse processes, not united at their distal ends. These processes are coössified with the sides of the centra, and their extremities are obliquely truncated for union with the ilia, which thus stand nearly vertical, or somewhat divergent above. The exact form of the ilium is not known with certainty, and in the diagram given in Plate VIII, figure 2, the outline is taken from the ilium of *Creosaurus*. The pubis is perhaps the most remarkable bone in the skeleton, and its determination and position solve many difficulties in the structure of the Dinosaurian pelvis, especially in the Carnivorous types. At its proximal end, this bone has four well-marked articular faces; one in front for the ilium; next the acetabular face; an oblique face for the ischium; and below this another, of about equal size, to which a separate bone was apparently articulated. Judging from the structure of the pelvis in *Laosaurus*, this bone should be the postpubis, and it is so indicated in the figure (Plate VIII, figure 2, p'). The shaft of the pubis is slender, and the distal end is expanded longitudinally, and firmly coössified with its fellow. The two seen from the front resemble an acute letter V. This type of pubic bone has long been a puzzle to anatomists, and portions of it have been referred to various parts of the skeleton. The ischia, also, are closely united on the middle line throughout the distal half, but are not ankylosed. This makes the entire pelvic arch a remarkably narrow one.

The large bones in *Allosaurus* are hollow, and the metatarsals slender. The terminal phalanges were armed with sharp claws. With the remains described above, a large spine was found, similar in general form to that of *Omosaurus armatus* described by Owen.

The type of *Allosaurus* is *A. fragilis*,* the remains of which indicate a reptile probably twenty-five feet in length, and of slender proportions.

The genus *Creosaurus* appears to be most nearly related in its vertebræ and ilium to *Megalosaurus*. It has apparently one less vertebra in its sacrum, and the ilium has in front of its pubic process an articular face which has not been observed in the latter genus. The position of this surface is indicated in Plate X, figure 1, *f*, and it may have supported a prepubic bone. The sacral vertebræ are elongated, and the transverse processes are placed higher up on the centra than those in *Allosaurus*. The teeth in both genera are of the *Megalosaurus* type, and in the whole group are so similar as to be of little value for the determination of species. The type of *Creosaurus*, is *C. atrox*,† a reptile about twenty feet in length.

A third genus of carnivorous Dinosaurs contains individuals of somewhat smaller size, and of this group the species named *Allosaurus lucaris*‡ is the type. The cervical vertebræ are short and strongly opisthocœlian, and the dorsals moderately so. All these vertebræ have very large cavities in the centra, which connect with the exterior by a comparatively small foramen on each side. The neural spines of the dorsal vertebræ are elevated and transverse, and the vertebræ now known do not show the diplosphenal articulation. The fore limbs in this genus are quite small, and the humerus is curved, and has a large radial crest. This genus is distinct fron *Allosaurus*, and may be called *Labrosaurus*, the type being *Labrosaurus lucaris*.

All of the carnivorous Dinosaurs known from the Atlantosaurus beds appear to have moved mainly on the posterior limbs. The large bones were hollow, and many of the vertebræ, as well as some of the feet bones, contained cavities, or were otherwise lightened to facilitate rapid movement.

The reptilian remains described in these two communications are preserved in the Museum of Yale College. In addition to these fossils, the collection contains a large quantity of similar specimens, from the same localities and horizon, some of which pertain to the same skeletons as those here illustrated. The careful investigation of this entire series will require much time, but promises important results.

* This Journal, vol. xiv, p. 515. † Ibid., vol. xv, p. 243.
‡ Ibid., vol. xv, p. 242.

The descriptions and illustrations given in this and the preceding article make clear the general structure of the Dinosaurian pelvic arch, which has so long been in doubt. In the *Sauropoda*, the elements of this arch are seen united in forms that admit of direct comparison with other more typical reptiles, each genus of the group having its own special features. In the smaller, more specialized, herbivorous forms, exemplified by *Laosaurus*, an advance is seen, especially in the pubic elements, where the long rod-like avian bone is fully developed, and the anterior part, or true reptilian pubis, is still prominent. In the Carnivorous forms represented by *Allosaurus*, a more complicated structure is seen to exist, but additional material will be necessary to elucidate it fully. In the pelves of the recent birds, given in Plate IX, the remnant of the reptilian pubis is still plainly to be seen, especially in *Geococcyx*. It is not improbable that the retention of this process may be due in part to the habits of certain species, as it seems to be best developed in running birds, and those that especially use the posterior limbs. The same process, apparently, is seen in some mammals, where it may serve a similar purpose. The ilium and ischium undergo but comparatively little change from the *Sauropoda* to recent birds. The sacrum, however, is gradually strengthened by the addition of vertebræ, and their more perfect coössification.

Yale College, New Haven, December 27, 1878.

[To be continued.]

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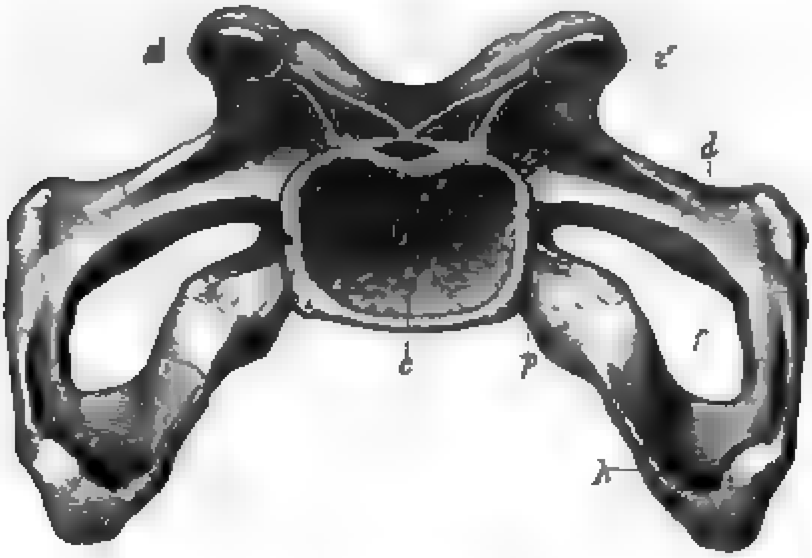

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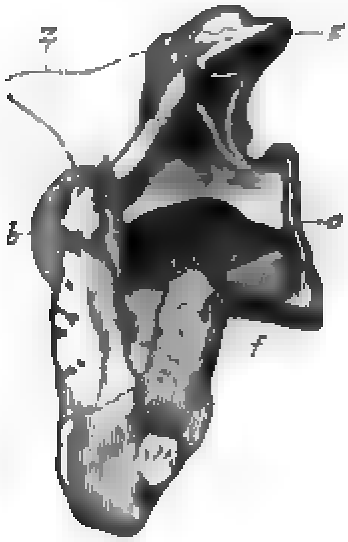

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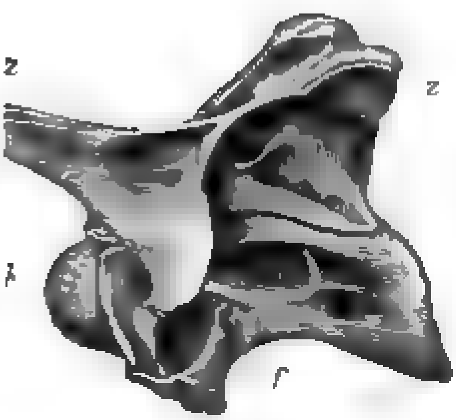

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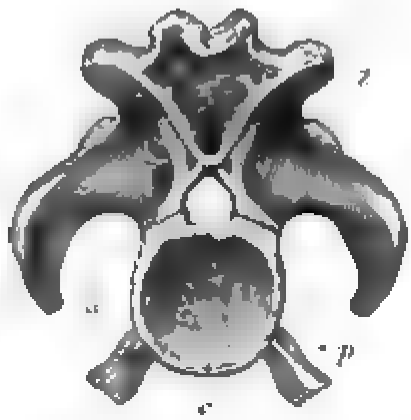
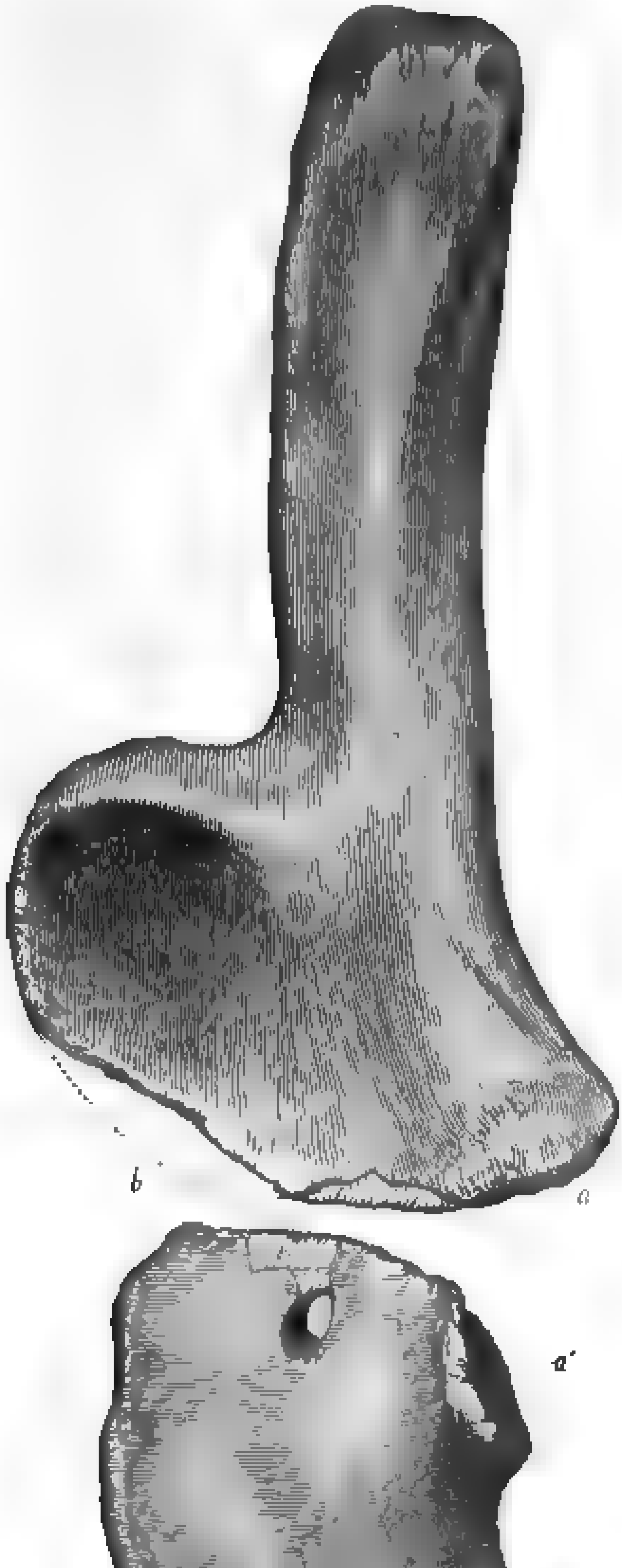
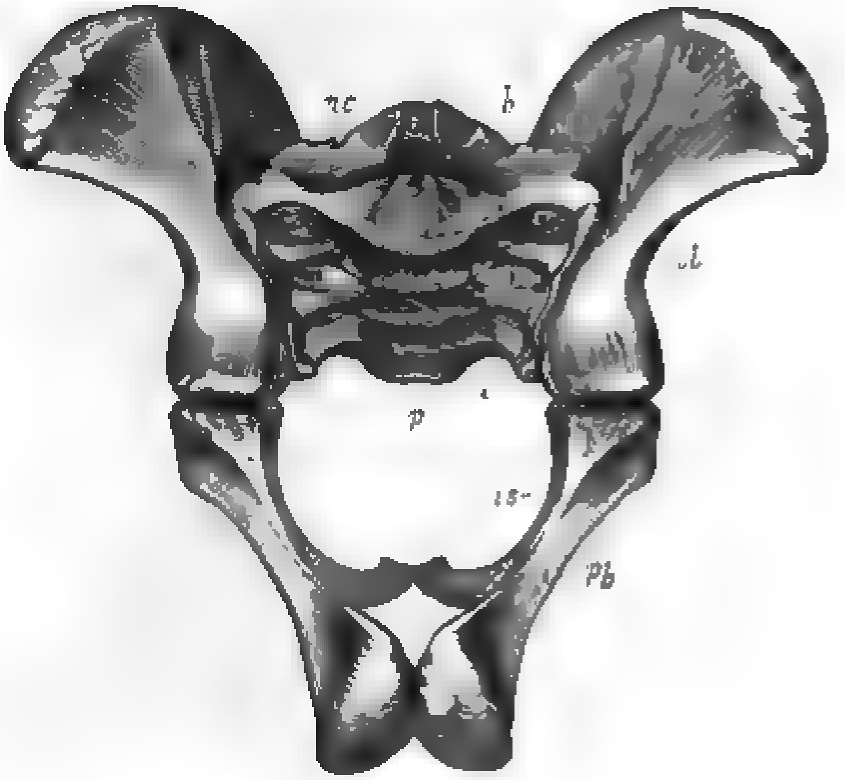


ure 1.—Cervical vertebra of *Apatosaurus laticollis* Marsh; back view
ure 2.—The same; side view. Both one-sixteenth natural size.
ure 3.—Fourth cervical vertebra of *Morosaurus grandis* Marsh; side view, ne-eighth natural size.
ure 4.—The same; back view.
signification of the letters is the same in all the figures, viz: *b.* ball; cup: *d.* diapophysis, *p.* parapophysis; *h.* hatchet bone; *f.* foramen in entrum; *f′* lateral foramen, *z.* anterior zygapophysis; *z′* posterior ygapophysis.



Left scapula and coracoid of *Apatosaurus ajax* Marsh, **one-fourteenth natural size.** *a*, **scapular face of** glenoid cavity, *b*, rugose surface **for union with coracoid; *a'* coracoidean part of** glenoid cavity; *f* foramen in coracoid.

1.



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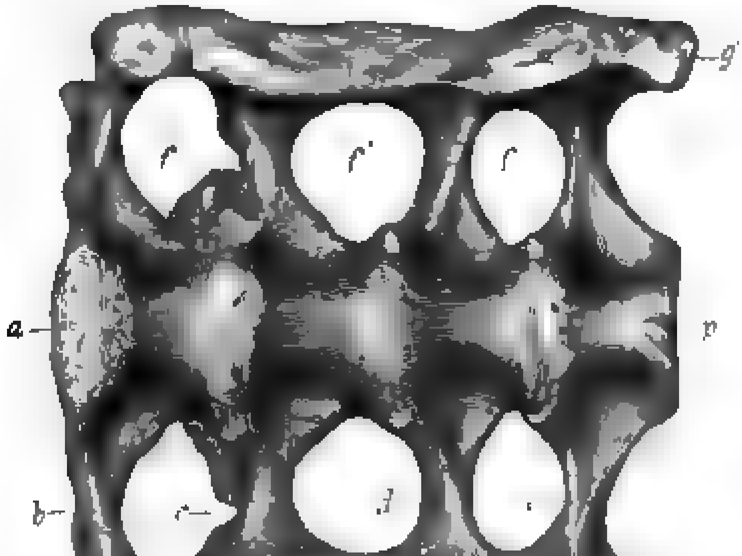

Figure 1.—Pelvic arch of *Morosaurus grandis* Marsh, seen from in front. One-sixteenth natural size.

Figure 2.—Sacrum of *Morosaurus grandis*; seen from below. One-tenth natural size.

a. first sacral vertebra; *b*. transverse process of first sacral vertebra; *c* transverse process of second vertebra; *d* transverse process of third vertebra; *e*. transverse process of last sacral vertebra *f* foramen between processes of first and second vertebra; *f'* foramen between second and third processes; *f''*. foramen between third and last process; *g*. surface for union with right ilium; *g'*. same for left ilium, *p*. fourth, or last, sacral vertebra; *nc*. neural canal; *il*. ilium; *is*. ischium; *pb*. pubis.

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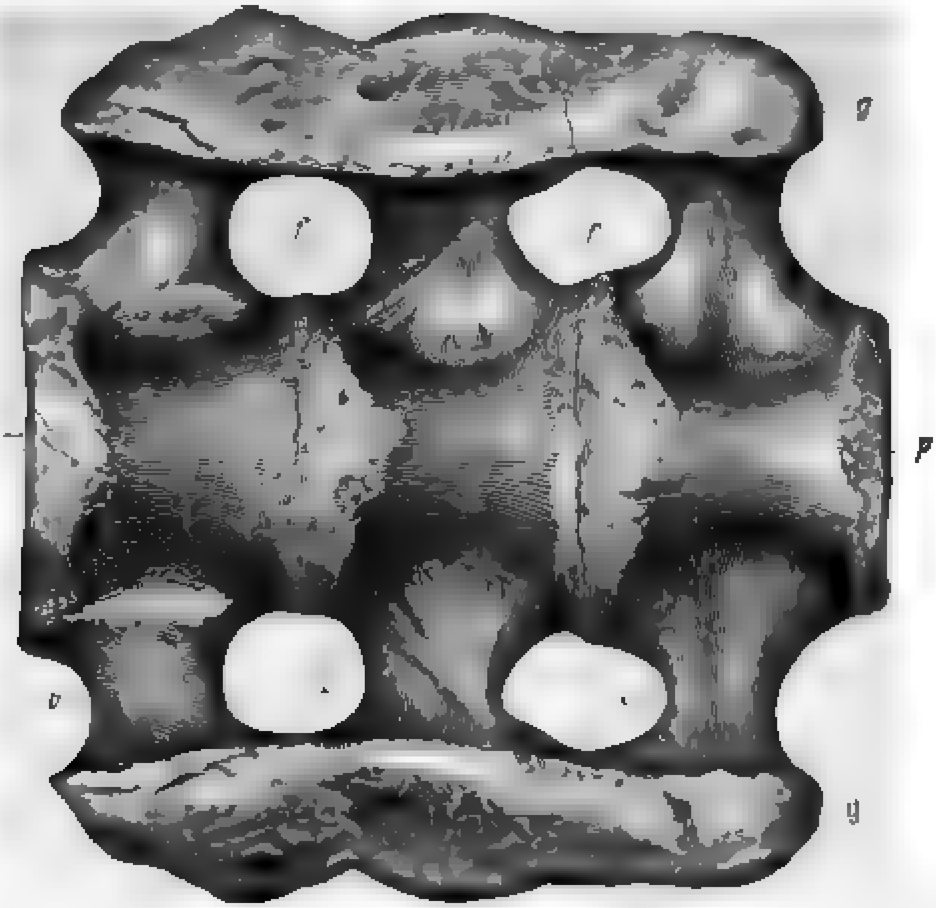

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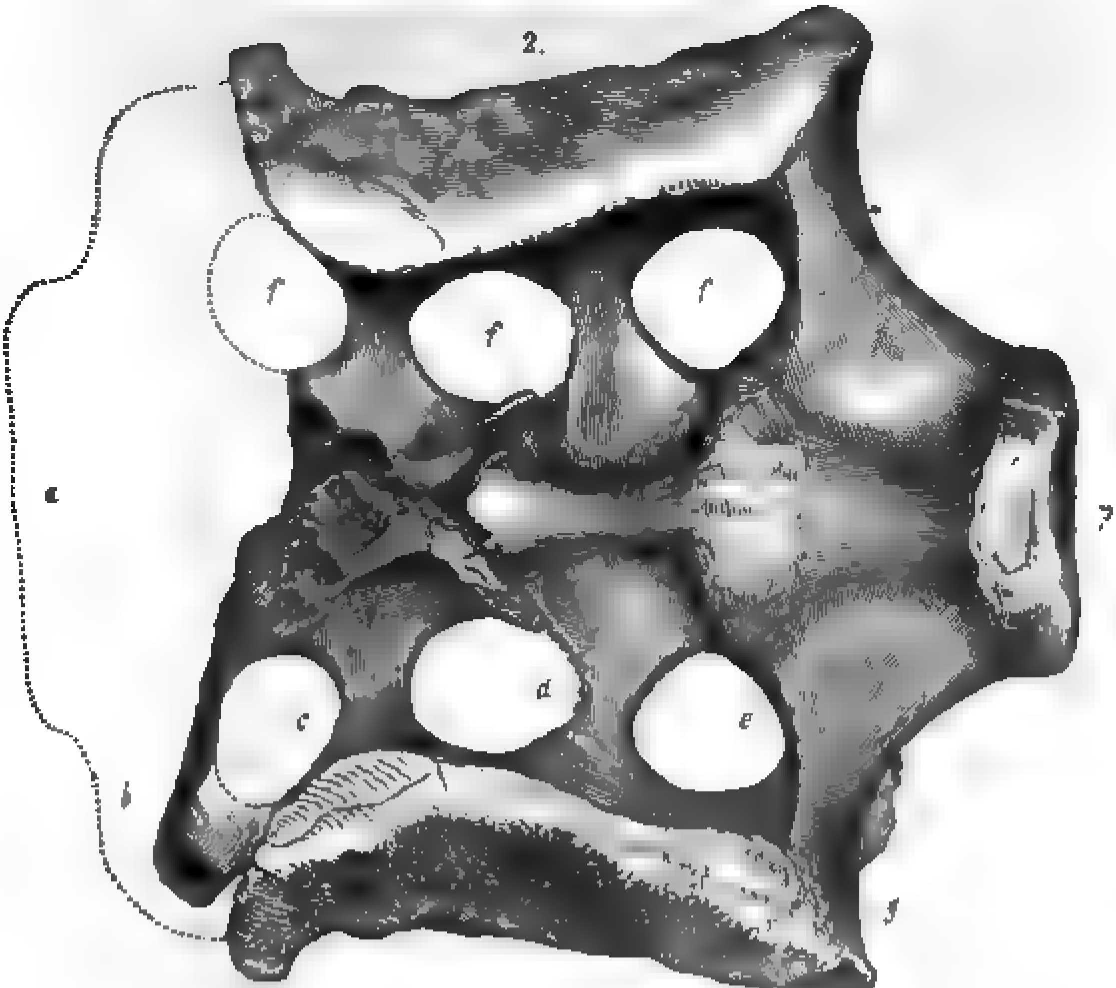

Figure 1.—Sacrum of *Apatosaurus ajax* Marsh; seen from below.
Figure 2.—Sacrum of *Atlantosaurus montanus* Marsh; seen from below; both one-tenth natural size.

***a.* first sacral vertebra;** *b.* transverse process of first vertebra; *c.* transverse **processes of second vertebra;** *d.* transverse process of third vertebra; ***f.* foramen between first** and second transverse processes; *f′.* foramen **between second and third processes;** *p.* last sacral vertebra; ***g.* surface for union with ilium.**

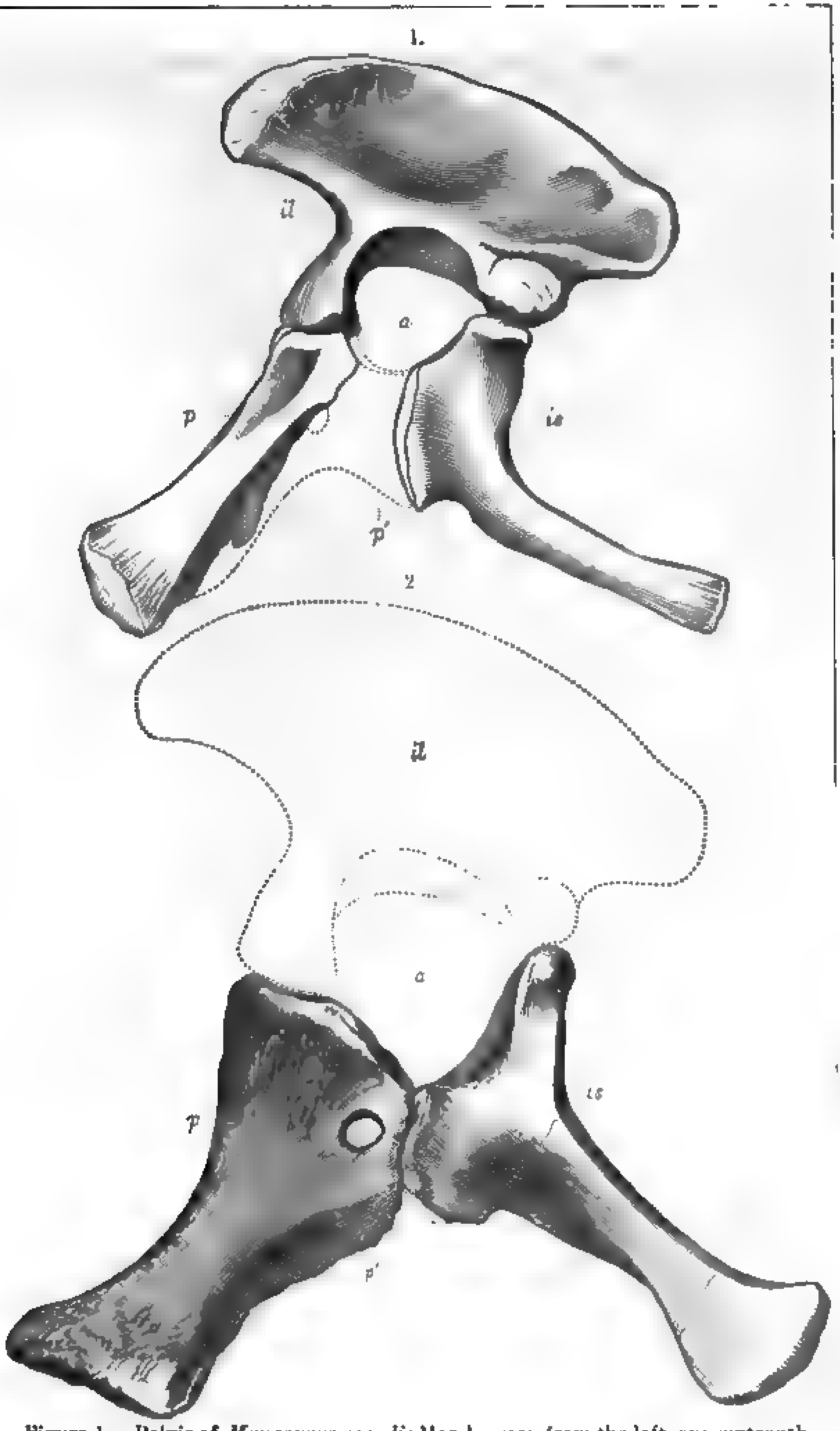

Figure 1.—Pelvis of *Morosaurus grandis* Marsh, seen from the left, one-sixteenth **natural size.**

Figure 2.—Pelvis of *Atlantosaurus immanis* Marsh, seen from the left, one-**twentieth natural size.** The signification of the letters is the same in both **figures, viz: *a*. acetabulum;** *f*. foramen in pubis; *il* ilium, *is* ischium; *p*. **pubis; *p'*. post-pubis.** In these and the following diagrams of Dinosaurian **pelves, the three bones of each are represented** nearly in the same plane.

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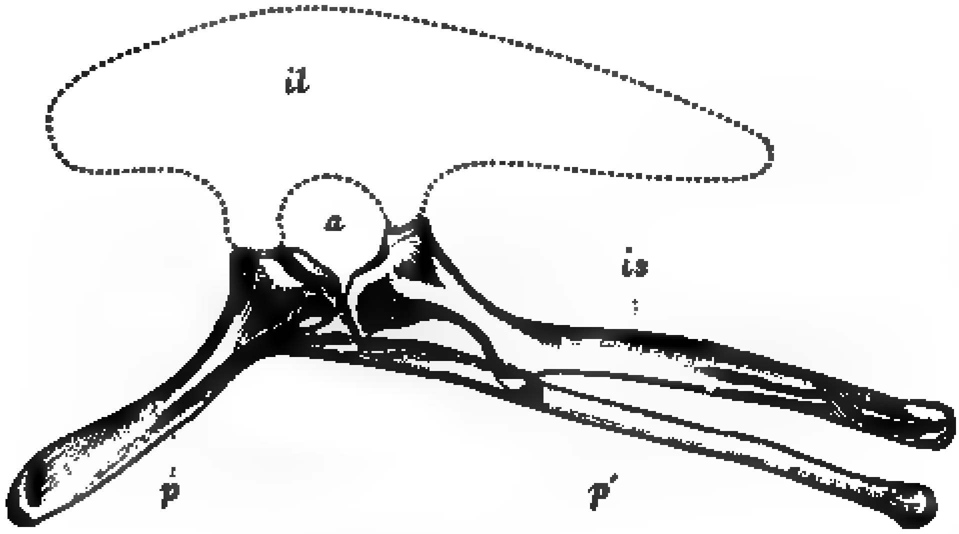

2.

gure 1.—Pelvis of *Laosaurus altus* Marsh; seen from the left, one-sixth natural size.

gure 2.—Pelvis of *Allosaurus fragilis* Marsh; seen from the left, one-twelfth natural size. The outline of the ilium is taken from *Creosaurus atrox* Marsh.

ıe signification of the letters is the same in both figures, viz: *a.* acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'* post-pubis; *f* articular facet on front of pubic process of ilium.

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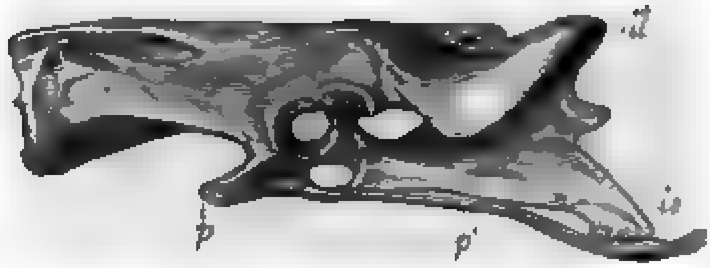

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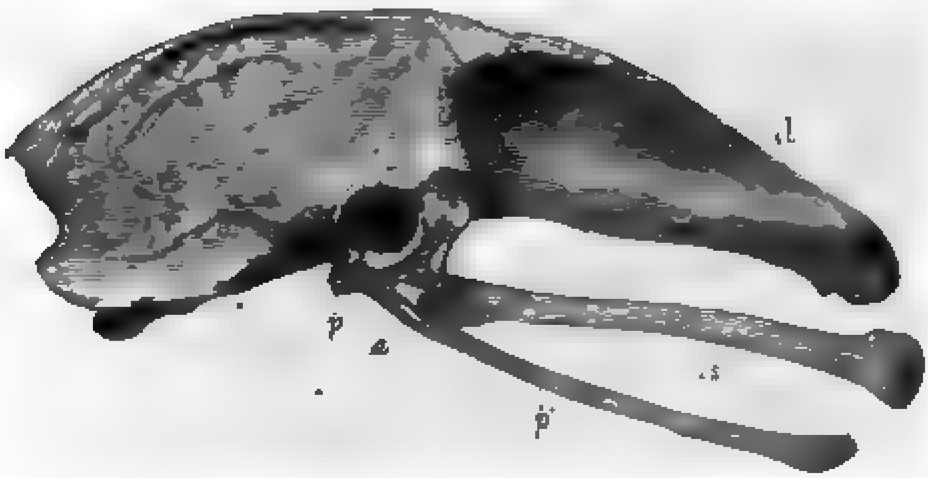
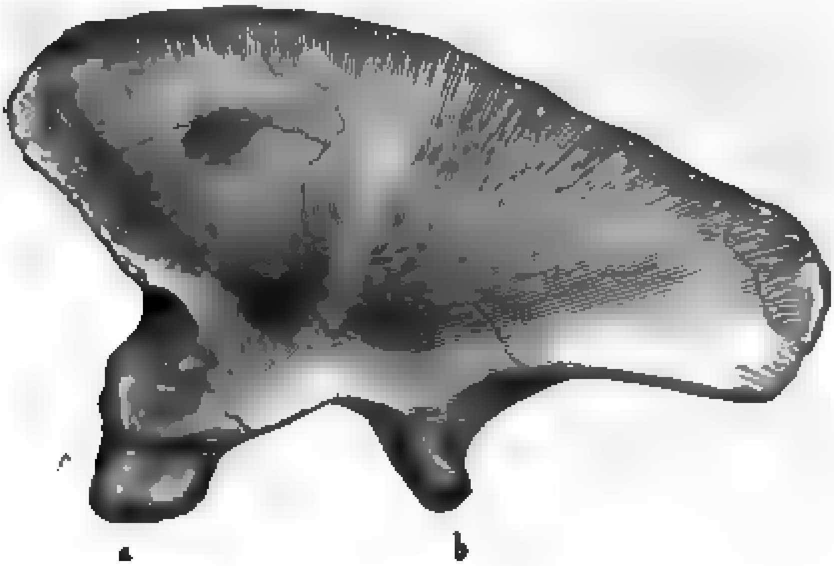


3.

Figure 1.—Pelvis of *Geococcyx Californianus* Baird; seen from the left, natural size.
Figure 2.—Pelvis of Emeu, *Dromaius novæ hollandiæ* Lath; one-fifth natural size.
Figure 3.—Pelvis of *Apteryx australis* Owen; three-fourths natural size.
a. acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis.

1.



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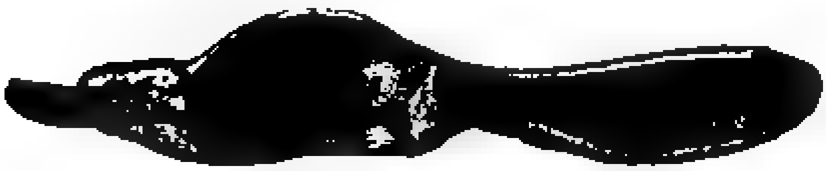


3.

4.

ure 1.—Left ilium of *Creosaurus atrox* Marsh; seen from the left.
ure 2.—The same: seen from below. Both one-tenth natural size.
.nterior, or pubic, articulation; *b*. posterior, or ischiadic, articulation:
articular facet on front of pubic process
ure 3. —Lumbar vertebra of *Allosaurus fragilis* Marsh; front view.
ure 4.—The same; side view, from the left. Both one-sixth natural size.
. anterior articular face; *p*. posterior articular face; *s* neural spine;
. diapophysis; z. anterior zygapophysis; z'. posterior zygapophysis.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XI.—*Discussion of the Working Hypothesis that the so-called Elements are Compound Bodies*;* by J. NORMAN LOCKYER, F.R.S.

IT is known to many Fellows of the Society that I have for the last four years been engaged upon the preparation of a map of the solar spectrum on a large scale, the work including a comparison of the Fraunhofer lines with those visible in the spectrum of the vapor of each of the metallic elements in the electric arc.

To give an idea of the thoroughness of the work, at all events in intention, I may state that the complete spectrum of the sun, on the scale of the working map, will be half a furlong (330 ft.) long; that to map the metallic lines and purify the spectra in the manner which has already been described to the Society, more than 100,000 observations have been made and about two thousand photographs taken.

In some of these photographs we have vapors compared with the sun, in others vapors compared with each other; and others again have been taken to show which lines are long and which are short in the spectra.

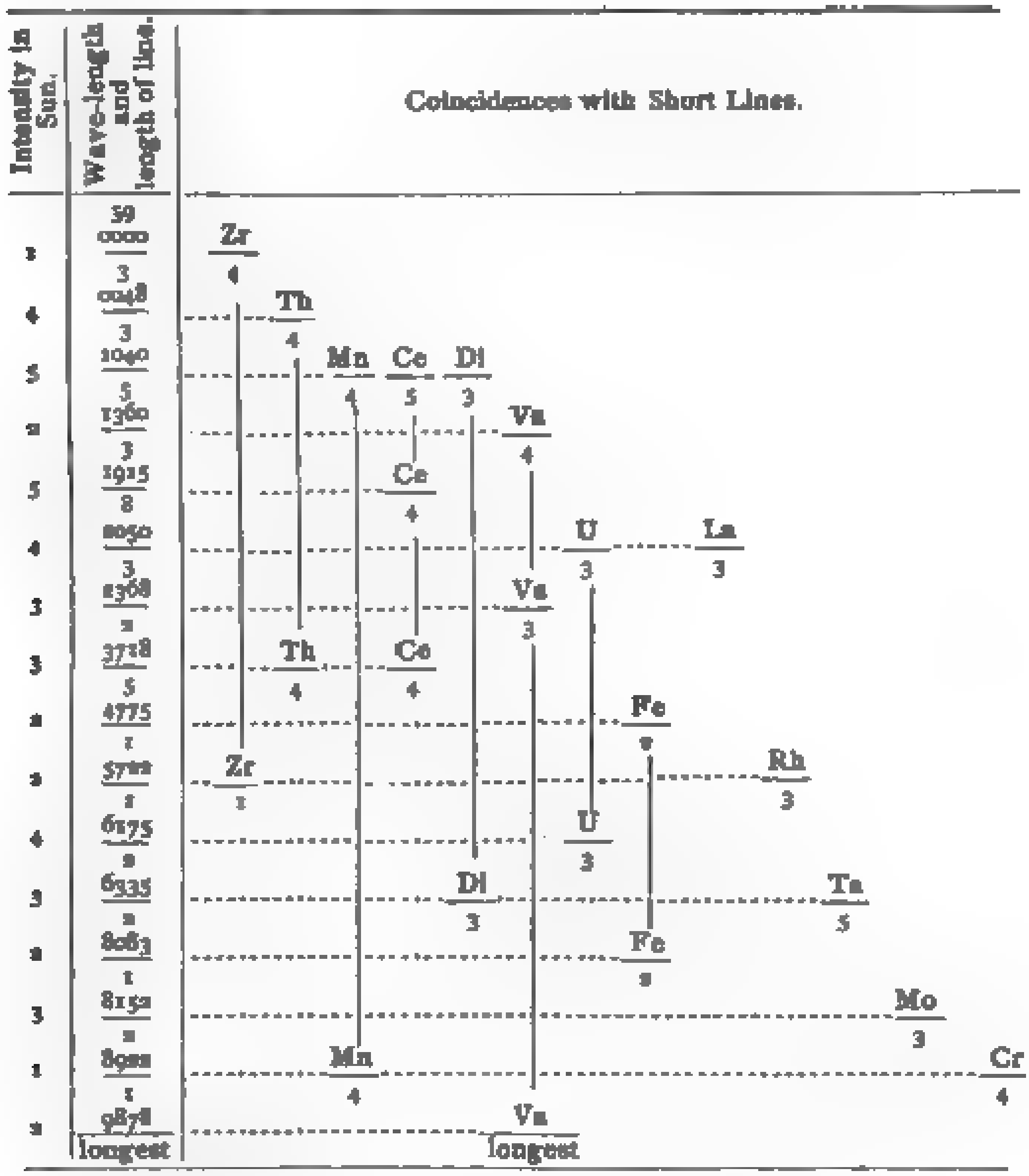
I may state in way of reminder that the process of purification consisted in this: When, for instance, an impurity of manganese was searched for in iron, if the longest line of Mn was absent, the short lines must also be absent on the hypothesis that the elements are elementary; if the longest line was present, then the impurity was traced down to the shortest line present.

* Paper read at the Royal Society, December 12, 1878.

TABLE I.—FINAL REDUCTION—IRON.

Intensity in Sun	Wave-length and length of line.	Coincidences with Short Lines.
1	39 0600 / 2	U 3, Zr 5, Yt 4
3	0622 / 4	Va 4
2	0980 / 3	Va 2, Ba 3
3	1010 / 4	Va 4, Pt 3
2	1648 / 2	Co 3
2	1755 / 3	Mn 3, Ce 4
2	1835 / 4	Os 2
1	2700 / 1	Va 2
1	2950 / 1	Mo 3
3	3083 / 4	Ce 4
5	3435 / 4	U 2
3	3475 / 2	Ba 2, Rh 2
3	3628 / 3	Ta 3
2	3975 / 2	Co 3
3	4026 / 3	Va 5
3	4422 / 4	Mo 3
3	4720 / 2	Yt 5, Th 3
2	5012 / 2	Di 2
2	5160 / 2	Ce 3, Ru 3
2	5210 / 3	W 1
2	5423 / 4	U 3, Mo 3, W 4
3	6215 / 3	Yt 5, Ce 3, Di 2
2	6571 / 2	Zr 2
3	6662 / 2	Th 1
1	7555 / 3	Os 2, Ta 4
3	7578 / 4	Di 2
2	7685 / 2	Va 4
2	8083 / 2	
1	8320 / 1	
3	9520 / 3	Ru 3
2	9750 / 2	Mo 3

TABLE II.—FINAL REDUCTION—TITANIUM.



The Hypothesis that the Elements are Simple Bodies does not include all the Phenomena.

The final reduction of the photographs of all the metallic elements in the region 39–40, a reduction I began in the early part of the present year, and which has taken six months, summarized all the observations of metallic spectra, compared with the Fraunhofer lines, accumulated during the whole period of observation. Now this reduction has shown me that the hypothesis that identical lines in different spectra are due to impurities is not sufficient. I shall show in detail in a subsequent paper the hopeless confusion in which I have been landed. I limit myself on the present occasion to giving tables showing how the hypothesis deals with the spectra of iron and titanium.

We find short line coincidences between many metals the impurities of which have been eliminated or in which the freedom from mutual impurity has been demonstrated by the absence of the longest lines.

Evidences of Celestial Dissociation.

It is five years since I first pointed out that there are many facts and many trains of thought suggested by solar and stellar physics which point to another hypothesis—namely, *that the elements themselves, or at all events some of them, are compound bodies.*

In a letter written to M. Dumas, December 3, 1873, and printed in the Comptes Rendus, I thus summarized a memoir which has since appeared in the Philosophical Transactions.

"Il semble que plus une étoile est chaude plus son spectre est simple, et que les éléments métalliques se font voir dans l'ordre de leurs poids atomiques.*

"Ainsi nous avons:

"1. Des étoiles très-brillantes où nous ne voyons que l'hydrogène, *en quantité énorme*, et le magnésium;

"2. Des é toiles plus froides, comme notre Soleil, où nous trouvons:

$$H+Mg+Na$$
$$H+Mg+Na+Ca, Fe, \ . \ . \ . \ ;$$

dans ces étoiles, pas de métalloïdes;

"3. Des étoiles plus froides encore, dans lesquelles *tous les éléments métalliques sont* ASSOCIÉS, où leurs lignes ne sont plus visibles, et où nous n'avons que les spectres des métalloïdes et des composés.

"4. Plus une étoile est âgée, *plus l'hydrogène libre disparaît;* sur la terre, nous ne trouvons plus d'hydrogène en liberté.

"Il me semble que ces faits sont les preuves de plusieurs idées émises par vous. J'ai pensé que nous pouvions imaginer une '*dissociation céleste*,' qui continue le travail de nos fourneaux, et que les métalloïdes sont des composés qui sont dissociés par la température solaire, pendant que les éléments métalliques monatomiques, dont les poids atomiques sont les moindres, son précisément ceux qui résistent, même à la température des étoiles les plus chaudes."

Before I proceed further, I should state that while observations of the sun have since shown that calcium should be introduced between hydrogen and magnesium for that luminary, Dr. Huggins' photographs have demonstrated the same fact for the stars, so that in the present state of our knowledge, independent of all hypotheses, the facts may be represented as follows:—

Hottest Stars	Lines of	H+Ca+Mg	
Sun........		H+Ca+Mg+Na+Fe	
Cooler Stars		— — Mg+Na+Fe+Bi+Hg	
Coolest	Fluted bands of	— — — — — —	Metalloids.

* This referred to the old numbers in which Mg=12, Na=23.

Following out these views, I some time since communicated)aper to the Society on the spectrum of calcium, to which I ıll refer more expressly in the sequel.

Differentiation of the Phenomena to be observed on the two Hypotheses.

When the reductions of the observations made on metallic ectra, on the hypothesis that the elements were really ele- entary, had landed me in the state of utter confusion to iich I have already referred, I at once made up my mind to r the other hypothesis, and therefore at once sought for a tical differentiation of the phenomena on the two hypotheses. Obviously the first thing to be done was to inquire whether e hypothesis would explain these short line coincidences iich remained after the reduction of all the observations on ; other. Calling for sake of simplicity the short lines common many spectra *basic lines*, the new hypothesis, to be of any lue, should present us with a state of things in which basic lecules representing bases of the so-called elements should 're us their lines, varying in intensity from one condition to other, the *conditions* representing various compoundings.

Suppose A (nickel, let us say) to contain B (cobalt) as an purity and as an element, what will be the difference in the ectroscopic result?

A in both cases will have a spectrum of its own;

B as an impurity will add its lines according to the amount impurity, as I have shown in previous papers.

B as an element will add its lines according to the amount dissociation, as I have also shown.

The difference in the phenomena, therefore, will be that, th gradually increasing temperature, the spectrum of A *will le*, if it be a compound body, as it will be increasingly disso- ted, and it *will not* fade if it be a simple one.

Again, on the hypothesis that A is a compound body, that one compounded of at least two similar or dissimilar molec- ır groupings, then the longest lines at one temperature will t be the longest at another, the whole fabric of "impurity mination," based upon the assumed single molecular group- ;, falls to pieces, and the origin of the basic lines is at once dent.

This may be rendered clearer by some general considerations another order.

General Considerations.

Let us assume a series of furnaces A . . . D, of which is the hottest.

Let us further assume that in A there exists a substance *a*

by itself competent to form a compound body β by union with itself or with something else when the temperature is lowered.

Then we may imagine a furnace B in which this compound body exists alone. The spectrum of the compound β would be the only one visible in B, as the spectrum of the assumed elementary body α would be the only one visible in A.

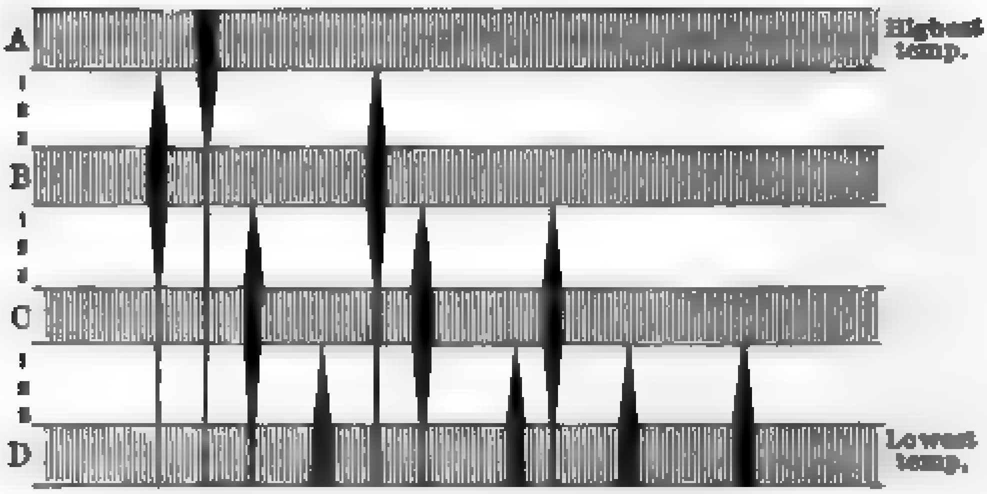


Fig. 1.

A lower temperature furnace C will provide us with a more compound substance γ, and the same considerations will hold good.

Now if into the furnace A we throw some of this doubly compound body γ we shall get at first an integration of the three spectra to which I have drawn attention; the lines of γ will first be thickest, then those of β, and finally α would exist alone, and the spectrum would be reduced to one of the utmost simplicity.

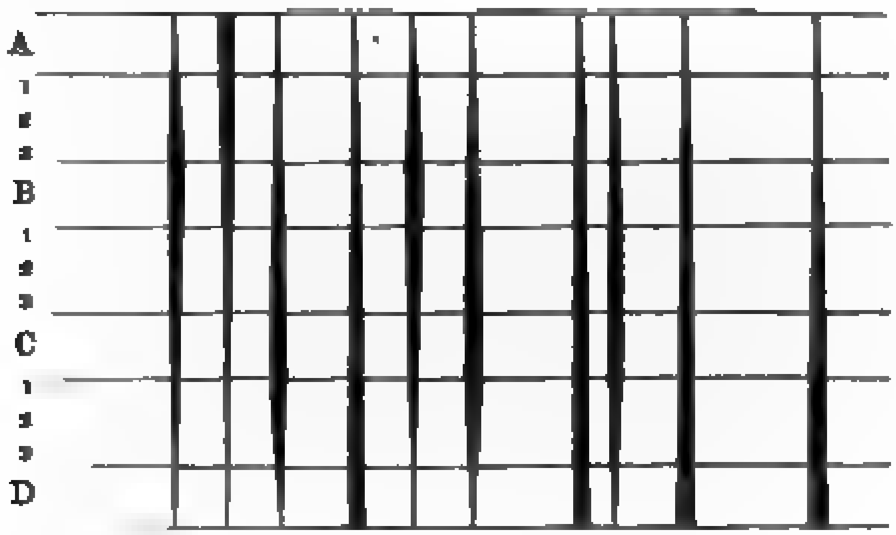


Fig. 2.

This is not the only conclusion to be drawn from these considerations. Although we have by hypothesis β, γ and δ, all higher, that is, more compound forms of α, and although the strong lines in the diagram may represent the true spectra of

these substances in the furnaces B, C and D, respectively, yet, in consequence of incomplete dissociation, the strong lines of β will be seen in furnace C, and the strong lines of γ will be seen in furnace D, *all as thin lines.* Thus, although in C we have no line which is not represented in D, the intensities of the lines in C and D are entirely changed.

In short, the line of a, strong in A, is *basic* in B, C and D, the lines of β, strong in B, are *basic* in C and D, and so on.

I have prepared another diagram which represents the facts on the supposition that the furnace A, instead of having a temperature sufficient to dissociate β, γ and δ into a is far below that stage, although higher than B.

It will be seen from this diagram that then the only difference in the spectra of the bodies existing in the four furnaces would consist merely in the relative thicknesses of the lines. The spectra of the substances as they exist in A would contain as many lines as would the spectra of the substances as they exist in D; each line would in turn be basic in the whole series of furnaces instead of in one or two only.

Applications of these General Considerations to Impurity Elimination.

Now let us suppose that in the last diagram (fig. 2) the four furnaces represent the spectra of say, iron, broken up into different finenesses by successive stages of heat. It is first of all abundantly clear that the relative thicknesses of the iron lines observed will vary according as the temperature resembles that of A, B, C, or D. The positions in the spectra will be the same, but the intensities will vary; this is the point. The longest lines, represented in the diagram by the thickest ones, will vary as we pass from one temperature to another. It is on this ground that I have before stated that the whole fabric of impurity elimination must fall to pieces on such an hypothesis. Let us suppose, for instance, that manganese is a compound of the form of iron represented in furnace B, with something else; and suppose again that the photograph of iron which I compare with manganese represents the spectrum of the vapor at the temperature of the furnace D. To eliminate the impurity of iron in manganese, as I have eliminated it, we begin the search by looking for the longest and strongest lines shown in the photograph of iron, in the photograph of manganese taken under the same conditions. I do not find these lines. I say, therefore, that there is no impurity of iron in manganese, but although the longest iron lines are not there, some of the faintest basic ones are. This I hold to be the explanation of the apparent confusion in which we are landed on the supposition that the elements are elementary.

Application of these Considerations to Known Compounds.

Now to apply this reasoning to the dissociation of a known compound body into its elements.—

A compound body, such as a salt of calcium, has as definite a spectrum as a simple one; but while the spectrum of the metal itself consists of lines, the number and thickness of some of which increase with increased quantity, the spectrum of the compound consists in the main of channelled spaces and bands, which increase in like manner.

In short, the molecules of a simple body and a compound one are affected in the same manner by quantity in so far as their spectra are concerned; *in other words, both spectra have their long and short lines*, the lines in the spectrum of the element being represented by bands or fluted lines in the spectrum of the compound; and in each case the greatest simplicity of the spectrum depends upon the smallest quantity, and the greatest complexity (a continuous spectrum) upon the greatest.

The heat required to act upon such a compound as a salt of calcium so as to render its spectrum visible, dissociates the compound according to its volatility; the number of true metallic lines which thus appear is a measure of the quantity of the metal resulting from the dissociation, and as the metal lines increase in number, the compound bands thin out.

I have shown in previous papers how we have been led to the conclusion that binary compounds have spectra of their own, and how this idea has been established by considerations having for a basis the observations of the long and short lines.

It is absolutely similar observations and similar reasoning which I have to bring forward in discussing the compound nature of the chemical elements themselves.

In a paper communicated to the Royal Society in 1874, referring, among other matters, to the reversal of some lines in the solar spectrum, I remarked,*—

"It is obvious that greater attention will have to be given to the precise *character* as well as to the position of each of the Fraunhofer lines, in the thickness of which I have already observed several anomalies. I may refer more particularly at present to the two H lines 3933 and 3968 belonging to calcium, which are much thicker in all photographs of the solar spectrum [I might have added that they were by far the thickest lines in the solar spectrum] than the largest calcium line of this region (4226·3), this latter being invariably thicker than the H lines in all photographs of the calcium spectrum, and remaining, moreover, visible in the spectrum of substances containing calcium in such small quantities as not to show any traces of the H lines.

* Phil. Trans., vol. clxiv, part 2, p. 807.

'How far this and similar variations between photographic ords and the solar spectrum are due to causes incident to photographic record itself, or to variations in the intensi- of the various molecular vibrations under solar and terres- conditions, are questions which up to the present time I re been unable to discuss."

An Objection Discussed.

was careful at the very commencement of this paper to nt out that the conclusions I have advanced are based upon analogies furnished by those bodies which, by common isent and beyond cavil and discussion are compound bodies. leed, had I not been careful to urge this point the remark ght have been made that the various changes in the spectra which I shall draw attention are not the results of succes- e dissociations, but are effects due to putting the same mass different kinds of vibration or of producing the vibration different ways. Thus the many high notes, both true and e, which can be produced out of a bell with or without its damental one, might have been put forward as analogous h those spectral lines which are produced at different de- es of temperature with or without the line, due to each sub- nce when vibrating visibly with the lowest temperature. this argument, however, if it were brought forward, the ly would be that it proves too much. If it demonstrates t the *h* hydrogen line in the sun is produced by the same lecular grouping of hydrogen as that which gives us two en lines only when the weakest possible spark is taken in drogen inclosed in a large glass globe, it also proves that cal- m is identical with its salts. For we can get the spectrum any of the salts alone without its common base, calcium, as can get the green lines of hydrogen without the red one.

I submit, therefore, that the argument founded on the over- tes of a sounding body, such as a bell, cannot be urged by y one who believes in the existence of any compound bodies all, because there is no spectroscopic break between acknowl- ged compounds and the supposed elementary bodies. The ctroscopic differences between calcium itself at different nperatures is, as I shall show, as great as when we pass from own compounds of calcium to calcium itself. There is a fect continuity of phenomena from one end of the scale of nperature to the other.

quiry into the Probable Arrangement of the Basic Molecules.

As the results obtained from the above considerations seemed be so far satisfactory, inasmuch as they at once furnished explanation of the *basic lines* actually observed, the inquiry s thought worthy of being carried to a further stage.

The next point I considered was to obtain a clear mental view of the manner in which, on the principle of evolution, various bases might now be formed, and then become basic themselves.

It did not seem unnatural that the bases should increase their complexity by a process of continual multiplication, the factor being 1, 2, or even 3, if conditions were available under which the temperature of their environment should decrease, as we imagined it to do from the furnace A down to furnace D. This would bring about a condition of molecular complexity in which the proportion of the molecular weight of a substance so produced in a combination with another substance would go continually increasing.

Another method of increasing molecular complexity would be represented by the addition of molecules of different origin. Representing the first method by A+A, we could represent the second by A+B. A variation of the last process would consist in a still further complexity being brought about by the addition of another molecule of B, so that instead of $(A+B)_2$ merely, we should have $A+B_2$.

Of these three processes the first one seemed that which it was possible to attack under the best conditions, because the consideration of impurities was eliminated; the prior work has left no doubt upon the mind about such and such lines being due to calcium, others to iron, and so forth. The inquiry took this form, granting that these lines are special to such and such a substance, does each become basic in turn as the temperature is changed?

I therefore began the inquiry by reviewing the evidence concerning calcium and seeing if hydrogen, iron and lithium behaved in the same way.

Application of the above Views to Iron, Lithium, and Hydrogen.

Calcium.—It was in a communication to the Royal Society made some time ago (Proceedings, vol. xxii, p. 380, 1874), that I first referred to the possibility that the well-known line-spectra of the elementary bodies might not result from the vibration of similar molecules. I was led to make the remark in consequence of the differences to which I have already drawn attention in the spectra of certain elements as observed in the spectrum of the sun and in those obtained with the ordinary instrumental appliances.

Later (Proc. Roy. Soc., No. 168, 1876) I produced evidence that the molecular grouping of calcium which, with a small induction-coil and small jar, gives a spectrum with its chief line in the blue, is nearly broken up in the sun, and quite broken up in the discharge from a large coil and jar, into another or others with lines in the violet.

I said "another," or "others," because I was not then able to determine whether the last named lines proceeded from the same or different molecules; and I added that it was possible we might have to wait for photographs of the spestra of the brighter stars before this point could be determined.

I also remarked that this result enabled us to fix with very considerable accuracy the electric dissociating conditions which are equivalent to that degree of dissociation at present at work in the sun.

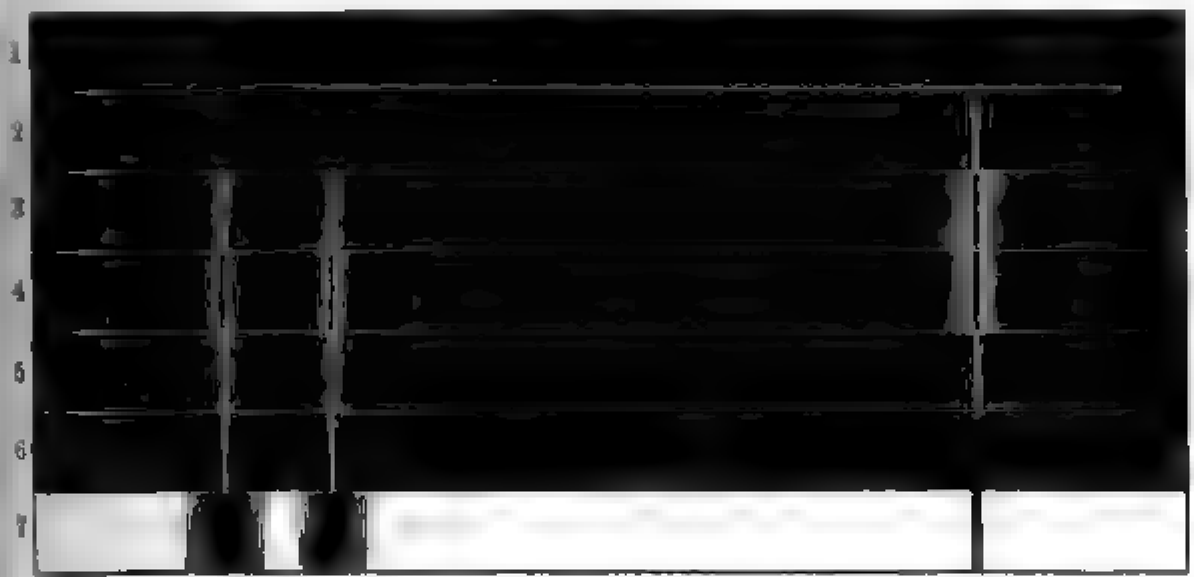


FIG. 3.—The blue end of the spectrum of calcium under different conditions. 1. Calcium is combined with chlorine ($CaCl_2$). When the temperature is low, the compound molecule vibrates as a whole, the spectrum is at the red end, and no lines of calcium are seen. 2. The line of the metal seen when the compound molecule is dissociated to a slight extent with an induced current. 3. The spectrum of metallic calcium in the electric arc with a small number of cells. 4. The same when the number of cells is increased. 5. The spectrum when a coil and small jar are employed. 6. The spectrum when a large coil and large jar are used. 7. The absorption of the calcium vapor in the Sun.

In fig. 3 I have collected several spectra copied from photographs in order that the line of argument may be grasped.

First we see what happens to the non-dissociated and the dissociated chloride. Next we have the lines with a weak voltaic arc, the single line to the right (W. L. 4226·3) is much thicker than the two lines (W. L. 3933 and 3968) to the left, and reverses itself.

We have next calcium exposed to a current of higher tension. It will be seen that here the three lines are almost equally thick, and all reverse themselves.

Now it will be recollected, that in the case of known compounds the band structure of the true compounds is reduced as dissociation works its way, and the spectrum of each constituent element makes its appearance. If in 3 we take the wide line as representing the banded spectrum of the compound, and the thinner ones as representing the longest elemental lines

making their appearance as the result of partial dissociation, we have, by hypothesis, an element behaving like a compound.

If the hypothesis be true, we ought to be able not only to obtain, with lower temperatures, a still greater preponderance of the single line, *as we do;* but with higher temperatures, a still greater preponderance of the double ones, *as we do.*

I tested this in the following manner: Employing photography, because the visibility of the more refrangible lines is small, and because a permanent record of an experiment, free as it must be from all bias, is a very precious thing.

Induced currents of electricity were employed in order that all the photographic results might be comparable.

To represent the lowest temperature I used a small induction coil and a Leyden jar only just large enough to secure the requsite amount of photographic effect. To represent the highest, I used the largest coil and jar at my disposal. The spark was then taken between two aluminium electrodes, the lower one cup-shaped, and charged with a salt of calcium.

In the figure I give exact copies of the results obtained. It will be seen that with the lowest temperature only the single line (2) and with the highest temperature only the two more refrangible lines (6) are recorded on the plate.

This proved that the intensity of the vibrations was quite changed in the two experiments.

Perhaps it may not be superfluous here to state the reasons which induced me to search for further evidence in the stars.

It is abundantly clear that if the so-called elements, or more properly speaking their finest atoms—those that give us line spectra—are really compounds, the compounds must have been formed at a very high temperature. It is easy to imagine that there may be no superior limit to temperature, and therefore no superior limit beyond which such combinations are possible, because the atoms which have the power of combining together at these transcendental stages of heat do not exist as such, or rather they exist combined with other atoms, like or unlike, at all lower temperatures. Hence association will be a combination of more complex molecules as temperature is reduced, and of dissociation, therefore, with increased temperature there may be no end.

That is the first point.

The second is this:—

We are justified in supposing that our "calcium," once formed, is a distinct entity, whether it be an element or not, and therefore, by working at it alone, we should never know whether the temperature produces a single simpler form or more atomic condition of the same thing, or whether we actually break it up into X+Y, because neither X nor Y will ever vary

But if calcium be a product of a condition of relatively lower temperature, then in the stars, hot enough to enable its constituents to exist uncompounded, we may expect these constituents to vary in quantity; there may be more of X in one star and more of Y in another; and if this be so, then the H and K lines will vary in thickness, and the extremest limit of variation will be that we shall only have H representing, say X in one star, and only have K representing, say Y in another. Intermediately between these extreme conditions we may have cases in which, though both H and K are visible, H is thicker in some and K is thicker in others.

Professor Stokes was good enough to add largely to the value of my paper as it appeared in the *Proceedings*, by appending a note pointing out that "When a solid body such as a platinum wire, traversed by a voltaic current, is heated to incandescence, we know that as the temperature increases not only does the radiation of each particular refrangibility absolutely increase, but the proportion of the radiations of the different refrangibilities is changed, the proportion of the higher to the lower increasing with the temperature. It would be in accordance with analogy to suppose that as a rule the same would take place in an incandescent surface, though in this case the spectrum would be discontinuous instead of continuous. Thus if A, B, C, D, E denote conspicuous bright lines of increasing refrangibility, in the spectrum of the vapor, it might very well be at that a comparatively low temperature A should be the brightest and the most persistent; at a higher temperature, while all were brighter than before, the relative brightness might be changed, and C might be the brightest and the most persistent, and at a still higher temperature E."

On these grounds Professor Stokes, while he regarded the facts I mentioned as evidence of the high temperature of the sun, did not look upon them as *conclusive* evidence of the dissociation of the molecule of calcium.

Since that paper was sent in, however, the appeal to the stars to which I referred in it has been made, and made with the most admirable results, by Dr. Huggins.

The result of that appeal is that the line which, according to Professor Stokes' view, should have prevailed over all others, as Sirius is acknowledged to be a hotter star than our sun, is that, if it exists at all in the spectrum, it is so faint that it was not recognized by Dr. Huggins in the first instance.

In Sirius, indeed, the H line due to one molecular grouping of calcium is as thick as are the hydrogen lines as mapped by Secchi, while the K line, due to another molecular grouping, which is equally thick in the spectrum of the sun, has not yet made its appearance.

In the sun, where it is as thick as H, the hydrogen lines have vastly thinned.

While this paper has been in preparation, Dr. Huggins has been good enough to communicate to me the results of his most important observations, and I have also had an opportunity of inspecting several of the photographs which he has recently taken. The result of the recent work has been to show that H and *h* are of about the same breadth in Sirius. In *a* Aquilæ while the relation of H to *h* is not greatly changed, a distinct approach to the solar condition is observed, K being now unmistakably present, although its breadth is small as compared with that of H. I must express my obligations to Dr. Huggins for granting me permission to enrich my paper by reference to these unpublished observations. His letter, which I have permission to quote, is as follows:—

"It may be gratifying to you to learn that in a photograph I have recently taken of the spectrum of *a* Aquilæ there is a line corresponding to the more refrangible of the solar H lines [that is K], but about half the breadth of the line corresponding to the first H lines.

In the spectra of *a* Lyræ and Sirius the second line is absent."

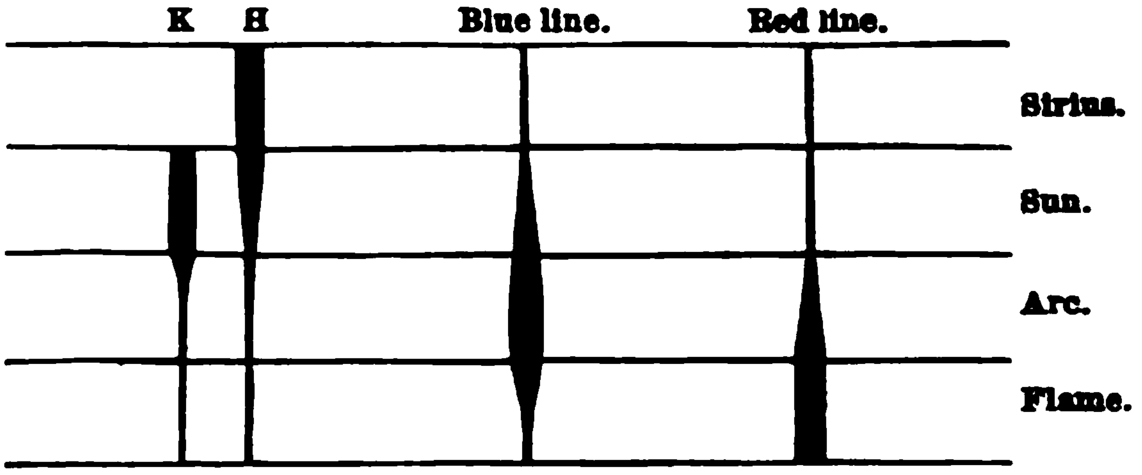


Fig. 4.—The Molecular Groupings of Calcium.

Professor Young's observations of the chromospheric line, to which I shall afterward refer, give important evidence regarding the presence of calcium in the chromosphere of the sun. He finds that the H and K lines of calcium are strongly reversed in every important spot, and that in solar storms H has been observed injected into the chromosphere seventy-five times, and K fifty times, while the blue line at W. L. 4226·3, the all-important line at the arc-temperature, was only injected thrice.

Further, in the eclipse observed in Siam in 1875, the H and K lines left the strongest record in the spectrum of the chromosphere, while the line near G in a photographic region of much greater intensity was not recorded at all. In the American eclipse of the present year the H and K lines of calcium were distinctly visible at the base of the corona, in which for the first time the observer could scarcely trace the existence of any hydrogen.

sum up, then, the facts regarding calcium, we have first the H-line differentiated from the others by its almost ·y existence in Sirius. We have the K-line differentiated the rest by its birth, so to speak, in *a* Aquilæ, and the ıess of its line in the sun, as compared to that in the arc. ave the blue line differentiated from H and K by its thin- ın the solar spectrum while they are thick, and by its ıess in the arc while they are thin. We have it again ːntiated from them by its absence in solar storms in which ıre almost universally seen, and finally, by its absence ; eclipses, while the H and K lines have been the bright- ːn or photographed. Last stage of all, we have calcium, guished from its salts by the fact that the blue line is only ː when a high temperature is employed, each salt having nite spectrum of its own, in which none of the lines to I have drawn attention appear, so long as the tempera- ; kept below a certain point.

Iron.

th regard to the iron spectrum I shall limit my remarks t portion of it visible on my photographic plates between l G. It may be described as a very complicated spectrum as the number of lines is concerned in comparison with bodies as sodium and potassium, lead, thallium, and the ɔut unlike them again it contains no one line which is y and unmistakably reversed on all occasions. Compared, ʳer, with the spectrum of such bodies as cerium and ım the spectrum is simplicity itself.

w among these lines are two triplets, two sets of three ːach, giving us beautiful examples of those repetitions of ure in the spectrum which we meet with in the spectra of t all bodies, some of which have already been pointed y Mascart, Cornu, and myself. Now the facts indicate hese two triplets are not due to the vibration of the same ular grouping which gives rise to most of the other lines. are as follows: In many photographs in which iron has ːompared with other bodies, and in others again in which as been photographed as existing in different degrees of ·ity in other bodies, these triplets have been seen almost and the relative intensity of them, as compared with the emaining lines, is greatly changed. In this these photo- s resemble one I took three years ago, in which a large nd jar were employed instead of the arc, which necessi- an exposure of an hour instead of two minutes. In this iplet near G is very marked, the two adjacent lines more gible near it, which are seen nearly as strong as the ; itself, in some of the arc photographs I possess, are only

very faintly visible, while dimmer still are seen the lines of the triplet between H and *h*.

There is another series of facts in another line of work. In solar storms, as is well known, the iron lines sometimes make their appearance in the chromosphere. Now, if we were dealing here with one molecular grouping, we should expect the lines to make their appearance in the order of their lengths, and we should expect the shortest lines to occur less frequently than the longest ones. Now, precisely the opposite is the fact. One of the most valuable contributions to solar physics that we possess is the memoir in which Professor C. A. Young records his observation of the chromospheric lines, made on behalf of the United States Government, at Shumar, in the Rocky Mountains. The glorious climate and pure air of this region, to which I can personally testify, enabled him to record phenomena which it is hopeless to expect to see under less favorable conditions. Among these were injections of iron vapor into the chromosphere, the record taking the form of the number of times any one line was seen during the whole period of observation.

Now two very faint and short lines close to the triplet near G were observed to be injected thirty times, while one of the lines of the triplet was only injected twice.

The question next arises, are the triplets produced by one molecular grouping or by two? This question I also think the facts help us to answer. I will first state by way of reminder that in the spark photograph the more refrangible triplet is barely visible, while the one near G is very strong. Now if one molecular grouping alone were in question this relative intensity would always be preserved however much the absolute intensity of the compound system might vary, but if it is a question of two molecules we might expect that in some of the regions open to our observation we should get evidence of cases in which the relative intensity is reserved or the two intensities are assimilated. What might happen does happen: the relative intensity of the two triplets in the spark photograph is grandly reversed in the spectrum of the sun. The lines barely visible in the spark photograph are among the most prominent in the solar spectrum, while the triplet which is strong in that photograph is represented by Fraunhofer lines not half so thick. Indeed, while the hypothesis that the iron lines in the region I have indicated are produced by the vibration of one molecule does not include all the facts, the hypothesis that the vibrations are produced by at least three distinct molecules includes all the phenomena in a most satisfactory manner.

Lithium.

Before the maps of the long and short lines of some of the chemical elements compared with the solar spectra, which were published in the Phil. Trans. for 1873, "Plate IX," were communicated to the Society, I very carefully tested the work of prior observers on the non-coincidence of the red and orange lines of that metal with the Fraunhofer lines, and found that neither of them were strongly if at all represented in the sun, and this remark also applies to a line in the blue at wave-length 4603.

The photographic lithium line, however, in the violet, has a strong representative among the Fraunhofer lines.

Applying, therefore, the previous method of stating the facts, the presence of this line in the sun differentiates it from all the others. For the differentiation of the red and yellow lines I need only refer to Bunsen's spectral analytical researches, which were translated in the Philosophical Magazine, December, 1875.

In Plate IV, two spectra of the lithium chloride are given, one of them showing the red line strong and the yellow one feeble, the other showing merely a trace of the red line, while the intensity of the yellow one is much increased, and a line in the blue is indicated. Another notice of the blue line of lithium occurs in a discourse by Professor Tyndall, reprinted in the Chemical News, and a letter of Dr. Frankland's to Professor Tyndall, dated November 7, 1861. This letter is so important for my argument, that I reprint it entire from the Philosophical Magazine, vol. xxii, p. 472:—

"On throwing the spectrum of lithium on the screen yesterday, I was surprised to see a magnificent blue band. At first I thought the lithium chloride must be adulterated with strontium, but on testing it with Steinheil's apparatus it yielded normal results without any trace of a blue band. I am just now reading the report of your discourse in the Chemical News, and I find that you have noticed the same thing. Whence does this blue line arise? Does it really belong to the lithium, or are the cone points or ignited air guilty of its production? I find there blue bands with common salt, but they have neither the definiteness nor the brilliancy of the lithium band. When lithium wire burns in air it emits a somewhat crimson light; plunge it into oxygen, and the light changes to bluish white. This seems to indicate that a high temperature is necessary to bring out the blue ray."

POSTSCRIPT, Nov. 22, 1861.—I have just made some further experiments on the lithium spectrum, and they conclusively prove that the appearance of the blue line depends entirely on the temperature. The spectrum of lithium chloride, ignited in a Bunsen's burner flame, does not disclose the faintest trace of

the blue line; replace the Bunsen's burner by a jet of hydrogen (the temperature of which is higher than that of the Bunsen's burner) and the blue line appears, faint, it is true, but sharp and quite unmistakable. If oxygen now be solely turned into the jet, the brilliancy of the blue line increases until the temperature of the flame rises high enough to fuse the platinum, and thus put an end to the experiment."

These observations of Professors Tyndall and Frankland differentiate this blue line from those which are observed at low temperatures. The line in the violet to which I have already referred, is again differentiated from all the rest by the fact that it is the only line in the spectrum of the sun which is strongly reversed, so far as our present knowledge extends. The various forms of lithium, therefore, may be shown in the following manner.

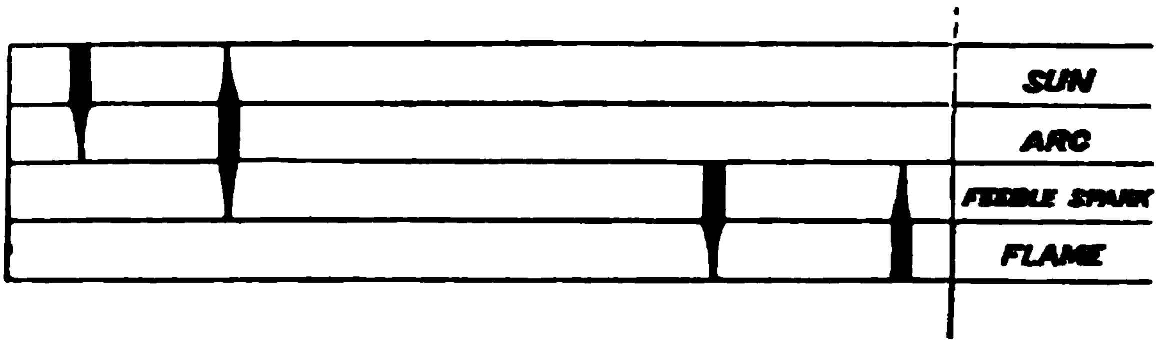


Fig. 5.—The Molecular Groupings of Lithium.

It is remarkable that in the case of this body which at relatively low temperature goes through its changes, its compounds are broken up at the temperature of the Bunsen burner. The spectrum, e. g. of the chloride, so far as I know, has never been seen.

Hydrogen.

All the phenomena of variability and inversion in the order of intensity presented to us in the case of calcium can be paralleled by reference to the knowledge already acquired regarding the spectrum of hydrogen.

Dr. Frankland and myself were working together on the subject in 1869. In that year (Proc., No. 112) we pointed out that the behavior of the *h* line was *hors ligne*, and that the whole spectrum could be reduced to one line, F.

"1. The Fraunhofer line on the solar spectrum, named *h* by Ångström, which is due to the absorption of hydrogen, is not visible in the tubes we employ with low battery and Leyden-jar power; it may be looked upon, therefore, as an indication of relatively high temperature. As the line in question has been reversed by one of us in the spectrum of the chromosphere, it follows that the chromosphere, when cool enough to absorb, is still of a relatively high temperature.

"2. Under certain conditions of temperature and pressure,

the very complicated spectrum of hydrogen is reduced in our instrument *to one line in the green* corresponding to F in the solar spectrum."

As in the case of calcium also, solar observation affords us most precious knowledge. The *h* line was missing from the protuberances in 1875, as will be shown from the accompanying extract from the Report of the Eclipse Expedition of that year:—

"During the first part of the eclipse two strong protuberances close together are noticed; on the limb towards the end these are partially covered, while a series of protuberances came out at the other edge. The strongest of these protuberances are repeated three times, an effect of course of the prism, and we shall have to decide if possible the wave-lengths corresponding to the images. We expect *a priori* to find the hydrogen lines represented. We know three photographic hydrogen lines: F, a line near G, and *h*. F is just at the limit of the photographic part of the spectrum, and we find indeed images of protuberances towards the less refrangible part at the limit of photographic effect. For, as we shall show, a continuous spectrum in the lower parts of the corona has been recorded, and the extent of this continuous spectrum gives us an idea of the part of the spectrum in which each protuberance line is placed. We are justified in assuming, therefore, as a preliminary hypothesis, that the least refrangible line in the protuberance shown on the photograph is due to F, and we shall find support of this view in the other lines. In order to determine the position of the next line the dispersive power of the prism was investigated. The prism was placed on a goniometer table in minimum deviation for F, and the angular distance between F and the hydrogen line near G, i. e. Hγ, was found, as a mean of several measurements to be 3′. The goniometer was graduated to 15″, and owing to the small dispersive power, and therefore relatively great breadth of the slit, the measurement can only be regarded as a first approximation. Turning now again to our photographs, and calculating the angular distance between the first and second ring of protuberances, we find that distance to be 3′ 15″. We conclude, therefore, that this second ring is due to hydrogen. We, therefore, naturally looked for the third photographic hydrogen line, which is generally called *h*, but we found no protuberance on our photographs corresponding to that wave-length. Although this line is always weaker than Hγ, its absence on the photograph is rather surprising, if it be not due to the fact that the line is one which only comes out at a high temperature. This is rendered likely by the researches of Frankland and Lockyer (Proc. Roy. Soc., vol. xvii, p. 453).

"We now turn to the last and strongest series of protuberances shown on our photographs. The distance between this series and the one we have found reason for identifying with $H\gamma$ is very little greater than that between $H\beta$ and $H\gamma$. Assuming the distances equal, we conclude that the squares of the inverse wave-lengths of the three series are in arithmetical progression. This is true as a first approximation. We then calculated the wave-length of this unknown line, and found it to be approximately somewhat smaller than 3,957 tenth-meters. No great reliance can be placed, of course, on the number, but it appears that the line must be close to the end of the visible spectrum.

"In order to decide if possible what this line is due to, we endeavored to find out both by photography and fluorescence whether hydrogen possesses a line in that part of the spectrum. We have not at present come to any definite conclusion. In vacuum tubes prepared by Geissler containing hydrogen, a strong line more refrangible than H is seen, but these same tubes show between $H\gamma$ and $H\delta$, other lines known not to belong to hydrogen, and the origin of the ultra-violet line is therefore difficult to make out. We have taken the spark in hydrogen at atmospheric pressures, as impurities are easier to eliminate, but a continuous spectrum extends over the violet and part of the ultra-violet, and prevents any observation as to lines. We are going on with experiments to settle this point.

"Should it turn out that the line is not due to hydrogen, the question will arise what substance it is due to. It is a remarkable fact that the calculated wave-length comes very close to H. Young has found that these calcium lines are always reversed in the penumbra and immediate neighborhood of every important sun-spot, and calcium must therefore go up high into the chromosphere. We draw attention to this coincidence, but our photographs do not allow us to draw any certain conclusions.

"At any rate, it seems made out by our photographs that the photographic light of the protuberances is in great part due to an ultra-violet line which does not certainly belong to hydrogen. The protuberances as photographed by this ultra-violet ray seem to go up higher than the hydrogen protuberances, but this may be due to the relative greater length of the line."

In my remarks upon calcium I have already referred to the fact that the line which our observation led us to believe was due to calcium in 1875, was traced to that element in this year's eclipse. The observations also show the curious connection that, at the time when the hydrogen lines were most brilliant in the corona, the calcium lines were not detected; next, when the

hydrogen lines, being still brilliant, the *h* line was not present (a condition of things which, in all probability, indicated a reduction of temperature), calcium began to make itself unmistakably visible; and finally, when the hydrogen lines are absent, they become striking objects in the spectrum of the corona.

To come back to *h*, then, I have shown that Dr. Frankland and myself, in 1869, found that it only made its appearance when a high tension was employed. We have seen that it was absent from among the hydrogen lines during the eclipse of 1875.

I have now to strengthen this evidence by the remark that it is always the shortest line of hydrogen in the chromosphere.

I now pass to another line of evidence.

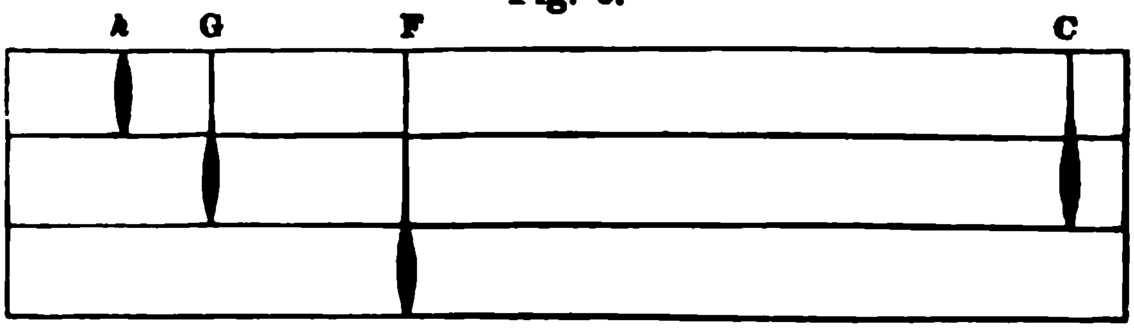
I submit to the Society a photograph of the spectrum of indium, in which, as already recorded by Thalèn, the strongest line is one of the lines of hydrogen (*h*), the other line of hydrogen (near G) being absent. I have observed the C line in the spark produced by the passage of an induced current between indium poles in dry air.

As I am aware how almost impossible it is to render air perfectly dry, I made the following differential experiment. A glass tube with two platinum poles about half an inch apart was employed. Through this tube a slow current of air was driven after passing through a U tube one foot high, containing calcium chloride, and then through sulphuric acid in a Wolff's bottle. The spectrum of the spark passing between the platinum electrodes was then observed, a coil with five Grove cells and a medium sized jar being employed. Careful notes were made of the brilliancy and thickness of the hydrogen lines as compared with those of air. This done, a piece of metallic indium which was placed loose in the tube, was shaken so that one part of it rested against the base of one of the poles, and one of its ends at a distance of little less than half an inch from the base of the other pole. The spark then passed between the indium and the platinum. The red and blue lines of hydrogen were then observed both by my friend, Mr. G. W. Hemming, Q.C., and myself. Their brilliancy was most markedly increased. This unmistakable indication of the presence of hydrogen, or rather of that form of hydrogen which gives us the *h* line alone *associated into* that form which gives us the blue and red lines, showed us that in the photograph we were not dealing with a physical coincidence, but that in the arc this special form of hydrogen had really been present; that it had come from the indium, and that it had registered itself on the photographic plate, although ordinary hydrogen persistently refuses to do so. Although I was satisfied from former experi-

ments that occluded hydrogen behaves in this respect like ordinary hydrogen, I begged my friend, Mr. W. C. Roberts, F.R.S., chemist to the Mint, to charge a piece of palladium with hydrogen for me. This he at once did, and I take this present opportunity to express my obligation to him. I exhibit to the Society a photograph of this palladium and of indium side by side. It will be seen that one form of hydrogen in indium has distinctly recorded itself on the plate, while that in palladium has not left a trace. I should add that the palladium was kept in a sealed tube till the moment of making the experiment, and that special precautions were taken to prevent the two pieces between which the arc was taken becoming unduly heated.

To sum up, then, the facts with regard to hydrogen: we have *h* differentiated from the other lines by its appearance alone in indium, by its absence during the eclipse in 1875, when the other lines were photographed by its existence as a short line only in the chromosphere of the sun, and by the fact that in the experiments of 1869 a very high temperature was needed to cause it to make its appearance.

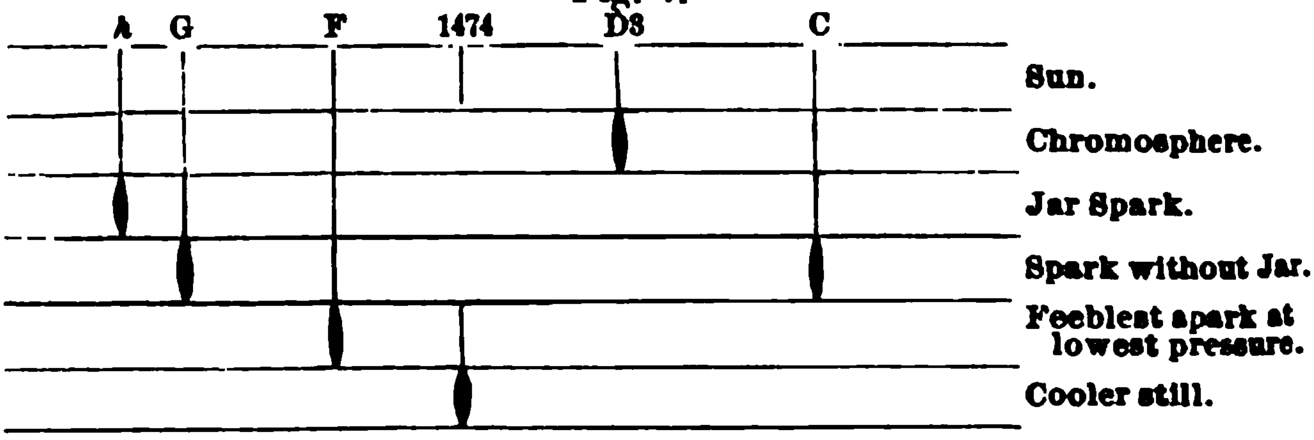
Fig. 6.



With regard to the isolation of the F line I have already referred to other experiments in 1869, in which Dr. Frankland and myself got it alone. I exhibit to the Society a globe containing hydrogen which gives us the F line without either the red or the blue one.

The accompanying drawing (Fig. 6) shows how these lines are integrated in the spectra of the sun.

Fig. 7.



I have other evidence which leads to the conclusion that the substance which gives us the non-reversed line in the chromosphere and the line 1474 of Kirchoff's scale, termed the coronal line, are really other forms of hydrogen. One of these is more

simple than that which gives us *h* alone, the other more complex than that which gives us F alone. The evidence on this point is of such extreme importance to solar physics and throws so much light on star structure generally, that I shall reserve it for a special communication.

In the meantime I content myself by giving a diagram (Fig. 7) in which I have arranged the various groupings of hydrogen as they appear to exist, from the regions of highest to those of lowest temperature in our central luminary.

Summation of the above Series of Facts.

I submit that the facts above recorded are easily grouped together, and a perfect continuity of phenomena established on the hypothesis of successive dissociations analogous to those observed in the cases of undoubted compounds.

The other Branches of the Inquiry.

When we pass to the other possible evolutionary processes to which I have before referred, and which I hope to discuss on a future occasion, the inquiry becomes much more complicated by the extreme difficulty of obtaining pure specimens to work with, although I should remark that in the working hypothesis now under discussion, the cause of the constant occurrence of the same substance as an impurity in the same connection is not far to seek. I take this opportunity of expressing my obligations to many friends who have put themselves to great trouble in obtaining specimens of pure chemicals for me during the whole continuance of my researches. Among these I must mention Dr. Russell, who has given me many specimens prepared by the lamented Matthiessen, as well as some of cobalt and nickel prepared by himself; Prof. Roscoe, who has supplied me with vanadium and cæsium alum; Mr. Crookes, who has always responded to my call for thallium; Mr. Roberts, chemist to the Mint, who has supplied me with portions of the gold and silver trial plates and some pieces of palladium; Dr. Hugo Müller, who has furnished me with a large supply of electrolitically-deposited copper; Mr. Holtzman, who has provided me with cerium, lanthanum, and didymium prepared by himself; Mr. George Matthay, of the well-known metallurgical firm of Johnson and Matthay, who has provided me magnesium and aluminium of marvellous purity; while to Mr. Valentin, Mr. Mellor, of Salford, and other friends, my thanks are due for other substances.

I have already pointed out that a large portion of the work done in the last four years has consisted in the elimination of the effects of impurities. I am therefore aware of the great necessity for caution in the spectroscopic examination of various

substances. There is, however, a number of bodies which permit of the inquiry into their simple or complex nature being made in such a manner that the presence of impurities will be to a certain extent negligable. I have brought this subject before the Royal Society at its present stage, in the hope that possibly others may be induced to aid inquiry in a region in which the work of one individual is as a drop in the ocean. If there is anything in what I have said, the spectra of all the elementary substances will require to be re-mapped and re-mapped from a new standpoint: further, the arc must replace the spark, and photography must replace the eye. A glance at the red end of the spectrum of almost any substance incandescent in a voltaic arc in a spectroscope of large dispersion, and a glance at the maps prepared by such eminent observers as Huggins and Thalen, who have used the coil, will give an idea of the mass of facts which have yet to be recorded and reduced before much further progress can be made.

In conclusion I would state that only a small part of the work to which I have drawn attention is my own. In some cases I have merely, as it were, codified the work done by other observers in other countries. With reference to that done in my own laboratory, I may here repeat what I have said before on other occasions, that it is largely due to the skill, patience, and untiring zeal of those who have assisted me. The burthen of the final reduction, to which I have before referred, has fallen to Mr. Miller, my present assistant; while the mapping of the positions and intensities of the lines was done by Messrs. Friswell, Meldola, Ord, and Starling, who have successively filled that post.

I have to thank Corporal Ewings, R.E., for preparing the various diagrams which I have submitted to the notice of this Society.

ART. XII.—*On the Velocity of very Loud Sounds;* by WILLIAM W. JACQUES, Fellow of the Johns Hopkins University.

IT is very well known that the velocity of a musical sound is, within very wide limits, sensibly independent of its intensity and of its pitch. The experimental proof of this is that a piece of music, played by a military band at a considerable distance, comes to the ear of the observer with its harmony entirely undisturbed.

A consideration of the theory of the propagation of a musical sound too, shows that for sounds such as we ordinarily hear, in which the change of density from the rarified to the con-

nsed portion of the wave is small compared with the density the undisturbed air, the velocity should be independent both the intensity and the pitch.

When, however, we come to the consideration of a loud and arp shock or explosion, in which the disturbances are very olent and abrupt, we cannot be at all sure that the changes of nsity are negligibly small, and hence that the velocity of und for such cases would be a constant.

So little is known of the conditions in the case of the forma- n and propagation of sound from a center of explosion, and e mathematical considerations of such conditions as we may esume are so difficult, that we must look almost entirely to periment for our knowledge of the propagation of very ıd sounds. But our experimental evidence on this point is ry limited. Nearly all of the experiments that have been ıde upon the velocity of sound have been made with a can- ɪu and have not agreed remarkably well with each other; nor ıve the thermodynamic quantities calculated from them, on the pposition that the velocity is identical with that of a musical und, agreed very well with the values of the same quantities etermined by other methods. But we cannot say whether these rors are due to the character of the sound or to other causes.

The very short interval between the flash and the report of stroke of lightning, even when it takes place at a considerable istance, has been instanced* as a proof of the greater velocity f very loud sounds, but, so far as the writer is aware, this has ot yet been reduced to experiment.

The experiments of Regnault † in water pipes showed that ie velocity of a pistol report became slightly less each time ıat it was reflected along the pipe, but the change was very nall and its cause is doubtful.

The following paper contains an account of some automatic ıeasurements of the velocity of sound in the immediate icinity of a cannon. The results show that the velocity near cannon is considerably different from that at a distance and oint out a considerable error that has been introduced into the ıost important measurement of this quantity.

The experiments were made at the United States Arsenal in Vatertown, Mass.

The method used was an automatic measurement of the elocity at different distances, varying from ten to one hundred nd ten feet, from the mouth of the cannon, by means of a eries of membranes‡ electrically connected with a chronograph.

In the midst of a large level field was placed a six-pound rass field piece. In the rear of this, at distances of 10, 30, 50,

* Earnshaw, Phil. Mag., 1860. † Regnault's Memoirs.

‡ Regnault used membranes, though unlike these, in his water-pipe experiments.

70, 90 and 110 feet from the mouth of the cannon, were placed the membranes, elevated about three feet above the ground. These membranes consisted each of a hoop nine inches in diameter over which was stretched a sheet of thin rubber. To the center of the membrane, and on the side toward the cannon, was attached a very small shelf of polished brass. Upon this rested one end of a delicate steel spring, the other end being fixed to an independent support.

The wire that brought the current of electricity from the chronograph house was connected with the spring, and from the shelf a second wire returned to the chronograph. When the spring rested upon the shelf the circuit was closed. The passage of the sound wave, however, would move the membrane and break the circuit, causing a register on the chronograph. When the spring fell it rested upon a contact point from which a wire ran to the next membrane of the series, so that the circuit, immediately after being broken at the first membrane, was made again through the second, before the sound wave reached it. In this way the current could be transferred to all the membranes of the series and the successive breakings and makings of contact, as the sound wave passed each one, could be registered on a chronograph placed at a distance.

The chronograph used was of the Schultz form and consisted essentially of a rapidly and uniformly revolving cylinder of silver covered with lamp black, which was made one pole of the secondary coil of an inductorium, the primary coil of which was in circuit with the membranes. The other pole of the secondary coil was a fine metal point brought very near to the surface of the cylinder. When the primary circuit was broken or completed at the membranes, a spark passed between the metal point and the cylinder and made a fine dot in the lamp black. By the side of the point was an electrical tuning-fork which traced a sinuous curve of times on the lamp-blacked surface of the cylinder. The time could thus be measured to ·00001 of a second. All that was necessary then for the experiment was to choose a moment when the air was as nearly as possible at rest and then, the membranes being in order, to start the chronograph and fire the gun. The distances between the membranes were then accurately measured, the times of passage between successive membranes determined from the chronograph and the temperatures read off from thermometers placed at each membrane.

The experiment was many times repeated with the membranes interchanged, with different velocities and parts of the chronograph cylinder and with other precautions to prevent possible errors, but always with the same result. It was found that immediately in the rear of the cannon the

velocity of sound was less than at a distance, but that going further and further from the cannon, *the velocity of sound rose to a maximum considerably above the ordinary velocity and then fell gradually to about the velocity usually received.*

In order to determine whether the first low velocities were due, as was supposed, to the retarding influence of the bodily motion of the air around the cannon, it was pointed at right angles to its first position, when it was found that the maximum velocity came nearer to the cannon. Had the cannon been turned in the direction of the line of membranes the retardation would probably have become an acceleration. The experiment was, however, of course impracticable. That this apparent retardation was not due to the difference in time of action of the membranes, due to a variation of the force of the wave, is evident both from the very slight force required in either case and from the fact that the variation noticed is in the wrong direction.

The charge of powder was considerably varied and the heaviest charges, of course, caused the greatest deviation from the ordinary velocity.

The successive series of experiments, owing to differences in the charge and in the loading, gave different values of the velocity at any one place, but the facts above stated always remained the same.

Accordingly each series represents the condition of things better than the mean of several, and I have here given a table of three of the best series.

The first column represents the distance from the mouth of the cannon; the second the values of the corresponding velocities in the rear of the cannon, when the charge was one and a half pounds; the third when the charge was reduced to half a pound, and the last when the cannon was pointed at right angles to the line of membranes.

	Velocities reduced to 0° C.		
	Rear of cannon.		Side of cannon.
Interval.	1½ lbs.	½ lb.	
10– 30 feet.	1076 feet.	....	....
30– 50	1187	1032	1067
50– 70	1240	1091	1162
70– 90	1267	1120	1201
90–110	1262	1114	1188

The conclusions that we may draw from these experiments are: 1. That the velocity of sound is a function of its intensity. 2. That experiments upon the velocity of sound in which a cannon is used contain an error, probably due to the bodily motion of the air near the cannon. Evidently a musical sound of low intensity must be used for a correct determination of the velocity of sound.

ART. XIII.—*Has Lake Winnipeg discharged through the Minnesota within the last two hundred years?* by J. E. TODD.

AFTER reading General Warren's article in the December number of the Journal, I casually took up a copy of Stansbury's Report on Salt Lake. On page 152 I found a curious account of Baron La Hontan's Expedition up the "Long River" in 1689. The Baron states that he passed down the Wisconsin to the Mississippi, which he ascended nine days, when he "entered the mouth of the Long River, which looks like a lake full of bulrushes," up which he sailed for six weeks, but was prevented by the advance of the season from reaching its source. He learned from the natives, however, considerable about its upper course, which he incorporated in his map.

Captain Stansbury gives a map drawn in 1710 by John Senex, F.R.S., on which the discoveries of La Hontan are given. This represents the "Long River" as being like a long lake toward its source, and flowing nearly due east through 25° of longitude. Another curious point, it is represented as having a continuous water connection through the "Moingona" River with the Mississippi, at a point far south of its proper mouth, where La Hontan entered it.

La Hontan describes it as "all along very slack and easy, abating about three leagues," and the channel unusually straight. "Its banks," he says, "have a dismal prospect, and the water itself has an ugly taste; but then its usefulness atones for such inconveniences, for 'tis navigable with the greatest ease, and will bear barques of fifty tons."

That the "Long River" *may* have been the ancient Minnesota seems indicated, therefore, by their corresponding in position of their mouths, their similarity in breadth of stream and slowness of current. Moreover, the "Moingona" would then correspond to the Blue Earth and Des Moines, whose sources were formerly connected by "Union Slough," as shown by Dr. C. A. White, in his report on the Geology of Iowa.

The curious *eastward* direction of the Long River may possibly be explained partly by the strong eastward declination of the magnetic needle at that time, and partly by the strong desire of the Baron to find a way across the continent. Preconceived notions seem to have influenced him in several other of his statements and conclusions, but perhaps not more so than was customary in those days.

Tabor, Iowa, Dec., 1878.

r. XIV.—*On the Results of the Spectroscopic Observation of the olar Eclipse of July 29th*, 1878;* by GEORGE F. BARKER.

rofessor Henry Draper, M.D., Director of the Draper Eclipse Expedition:—

lear Sir: I beg leave to submit to you herewith my Report the spectroscopic observations made, and on the results iined at Rawlins, Wyoming Territory, during the solar ose of July 29th, 1878, that portion of the work having i allotted to me by yourself in the organization of the edition.

'he instruments and apparatus used in the observations e loaned for the purpose from the physical cabinet of the versity of Pennsylvania. They consisted (1) of an equaally mounted achromatic telescope of four inches aperture le by Jones of London, (2) a direct-vision astronomical ;troscope by Merz of Munich, (3) a second direct-vision ;troscope by Hoffmann of Paris, (4) and a pocket spectro-)e by George Wale & Co. Beside this spectroscopic outfit, cond four-inch achromatic telescope by Dollond was taken use with the tasimeter by Dr. Edison, and a Savart, a armont, and an Arago polariscope, for determining the arization of the corona. The Merz spectroscope above menied is described in the Philosophical Magazine, IV, xli, Feb. 1. It is provided with two compound direct-vision prisms, which one or both can be used at pleasure, each consisting ive single prisms, two of flint glass with a refracting angle 84°, and three of crown; one of these having a refracting le of 84°, the others of 87°. The dispersive power of each these compound prisms is about equal to that of two equiral prisms of flint glass. The instrument has a collimating . an observing telescope, each furnished with an object glass -thirds of an inch in aperture and four inches in focal length. e prism-tube is attached to the collimator by two centers, ing it a lateral motion about a line passing through these ters, which constitutes an axis parallel to the slit. The erving telescope is similarly attached to the tube carrying prism. These motions serve to alter the incidence of the s upon the surface of the prism, and also to bring any cial part of the spectrum into the middle of the field. The erving telescope is provided with a positive eye-piece of an iivalent focal length of one inch, and also with a needle rometer, having an eye-piece of one-half inch focus. The duations upon this micrometer are strongly cut, enabling the itions and the distances of the lines measured with it, to be

* Read by permission of Dr. Draper at the St. Louis meeting of the American ciation for the Advancement of Science.

easily read even in a faint light. The spectroscope was firmly attached to the draw tube of the equatorial telescope by means of an open frame made by Zentmayer, so that the position of the image with reference to the slit could be readily observed.

The time from the 19th of July, the date of our arrival at Rawlins, until the 29th, was occupied in setting up the instruments, in getting them into adjustment, and in practice with them. It was found that with only one of the compound prisms of the Merz spectroscope, the slit being placed radially, it was easy to observe the lines C and F reversed in the chromosphere, and also the bright line D_3. On the morning of the day of the eclipse, the solar edge was examined for protuberances, in order to locate them in advance of totality. But a single one was noticed, this being on the southwestern edge of the sun. As the time of first contact approached, the spectroscope was removed and a paper screen was attached to the draw tube, an image of the sun being formed on this screen by means of the eye-piece; thus enabling the time of this contact to be approximately determined and the subsequent progress of the eclipse to be conveniently observed. No spots were seen under these circumstances, though this could hardly have been expected since the solar image was so small, scarcely three inches in diameter, unless the spots were of large size. As the time of second contact drew near, the spectroscope was replaced upon the equatorial. Since you deemed it of importance to pay special attention to the oxygen lines in the vicinity of G, the micrometer of this instrument was, at your suggestion, so adjusted that one of its needle points rested on the hydrogen line near G, and the other on the line known as *h*. After the last ray of sunlight had disappeared, I took a few seconds of the precious time to observe the eclipse with the naked eye. The moon appeared intensely black, surrounded by a pinkish halo, extending to about two-fifths of a lunar diameter from the limb, and occupying the entire circumference. At two points this halo was expanded into radial streamers, one of which had parallel sides with a deeply indented or swallow-tailed end, extending westward of the sun and apparently lying in the ecliptic: the other appeared single, was on the eastern edge, and was inclined twenty degrees or more to the north of the ecliptic. The former of these streamers was traced to a distance of about a lunar diameter from the edge, the latter to a somewhat less distance. No structure could be seen in the halo, but in the streamers traces of parallel rays appeared to be present. The amount of light emitted by the corona was a surprise to me. Preparations had been made for using artificial light for reading the circles, but this was found not

be at all necessary. The amount of light seemed to be arly or quite equal to that given by the moon when ten days d. No protuberances were seen with the naked eye nor ere any streamers observed, other than those already scribed. A glance at the eclipsed sun was then taken rough the finder of the equatorial. The magnifying ower being low, the corona presented much the same pearance as to the naked eye. But the streamers showed uch more distinct evidences of a radiated structure and a le rosy protuberance was observed on the southwestern edge the dark disc. This was undoubtedly the same prominence hich was observed previous to totality.

Turning my attention now to the spectroscope, upon the slit which the coronal image had already been brought by means the finder, the slit being placed radially, the first glance rough the instrument showed me a bright but an absolutely ontinuous spectrum. The region under examination was of ourse that portion of the spectrum which had been placed efore totality between the needle-points of the micrometer. 'otally unprepared for so unexpected a result, I moved the bserving telescope so as to bring the green portion of the spec-rum into the field, expecting certainly to see 1474 K and by he appearance of this line to determine whether my instrument ras out of adjustment; and if it was to adjust it again. But no right line was there; the green region appeared as continuous s the blue. I then gradually closed the slit—which had been reviously adjusted on the solar spectrum so that the line D ppeared nebulous on its edges—thinking that I might in this vay improve the definition; but with no better result; no right lines could be seen. To my great surprise however, when the slit was thus narrowed, the region which was then inder examination, that extending from *b* to G, appeared filled with dark lines on the brighter background, these dark lines being readily recognized from their general appearance as the solar lines of Fraunhofer. Still intent on getting bright lines, I opened the slit again gradually, moved the observing tele-scope over the entire length of the spectrum from red to violet, repeating the operation three times and varying the width of the slit from time to time in each region; but not a single bright line could be detected. I then requested you to come and take a glance through my spectroscope, as had been pre-viously agreed; saying that although I could see dark lines and a continuous spectrum, I was unable to detect a single bright line and knew not what to make of it. You were then ooking at the eclipse through your ingenious little telespectro-cope of two inches aperture. You came to my instrument, ooked at the spectrum, moved the observing telescope over its

whole length and remarked that the results in my spectroscope agreed entirely with those in yours, and that the spectrum appeared in both absolutely continuous. My mind being thus relieved, I took my place again at the spectroscope, and this time, placing the slit tangential to the moon's limb, I moved the observing telescope from end to end of the spectrum, opening and closing the slit at intervals; but the spectrum appeared as continuous as before. Again the image was adjusted so that the slit was once more radial; and this time on still a different portion of the corona. On examining again the spectrum, no bright lines appeared, except once for an instant, when the slit passed over the small chromospheric prominence already noticed. Warned by Mrs. Draper's clear and distinct counting that the precious 165 seconds had two-thirds gone, I decided to devote the time still remaining to a more careful observation of the dark Fraunhofer lines. Now, for the first time, as I adjusted the width of the slit and its position on the corona with more care, I observed that these lines did not pass clear across the field, but were of a length corresponding to the width of the coronal image on the slit. At the base of the spectrum, which corresponded to the base of the corona, they appeared bright and sharp; certainly quite as much so as in the light of the moon similarly condensed; though the continuous spectrum which formed their background was relatively brighter than in moonlight. There was no difficulty in identifying them as Fraunhofer lines from their general appearance and position; but some of them could be identified beyond question. Such were *b* and F, which were especially distinct, and D, E and G which were considerably less so. They faded gradually out from the base of the spectrum upward, appearing to end where the continuous spectrum of the corona was limited above. While thus employed, a flash of sunlight told us that totality had ended and that the solar eclipse of 1878 was over.

In discussing the results of the spectroscopic observations which have now been detailed, I am, in the first place, quite at a loss to account for the fact that no bright lines were seen by me, notwithstanding the persistent efforts made to get them. The failure to observe them can be accounted for, as it would seem, only on the ground that with the dispersive power employed, the bright lines were too faint to be seen on the much brighter background of the continuous spectrum.

The lessons to be drawn from these spectroscopic observations appear to be few and simple. The absence of bright lines, or at least of any which were at all brilliant, proves clearly the absence in the solar coronal region of any considerable mass of incandescent gas or vapor, which shining by its own light would of course give a bright-line spectrum. The presence of

Fraunhofer lines in the coronal spectrum shows conclusively the presence of reflected sunlight in the light of the corona and goes to establish the theory, long ago suggested, that masses of meteoric matter raining down upon the solar surface from all directions reflected to us the light of the sun, and were, therefore, the essential cause of the coronal phenomena. And, finally, the fact of the increased brightness of the continuous spectrum, as compared with the intensity of the dark lines of Fraunhofer, goes to strengthen the probability that there is still other light in the corona which comes to us from the incandescent liquid or solid matter of these intensely heated meteoric masses. These conclusions, deduced very simply from my own spectroscopic results, agree completely, I am happy to find, with those drawn from your most excellent photographs, as well as from the ingenious heat-measurements of Dr. Edison and the polariscopic determinations of Dr. Morton.

In concluding this Report, you will permit me I am sure, to express the great gratification which the Draper Eclipse Expedition has continually afforded me. The delight at being able to witness a total eclipse of the sun, has been intensified by the complete success of all the attempts made to observe it, and by the most agreeable companionship during the trip. My obligation to you for the opportunity is as profound as my thanks to you for it are sincere and cordial.

Truly yours, GEORGE F. BARKER.

Philadelphia, August 10th, 1878.

ART. XV.—*On a mode of measuring the Velocity of Sound in Wood;* by MAGNUS C. IHLSENG, Ph.D.

[Read before the National Academy of Science, October, 1877.]

THE subject of this paper was suggested to me by Professor Rood, and the work carried out under his direction in the physical laboratory of Columbia College.

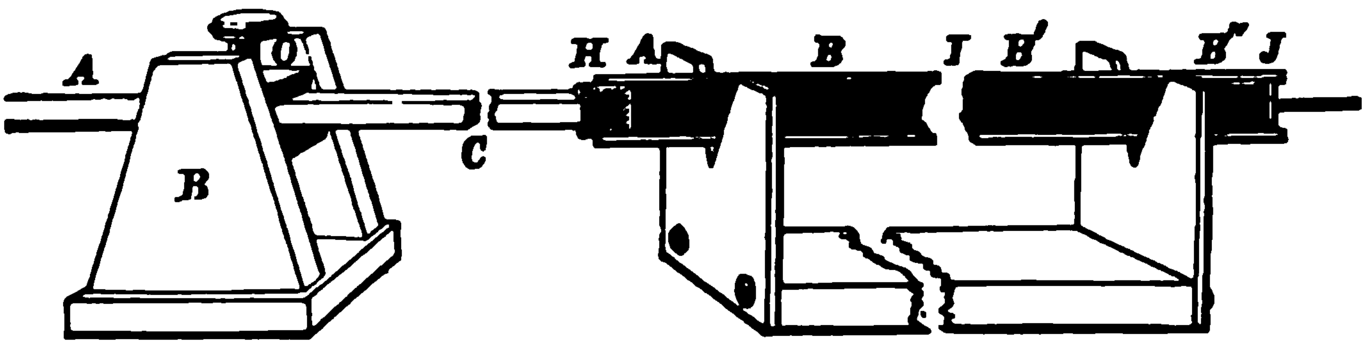
Since the study by Chladni of longitudinal vibration in rods, many researches upon this point have rendered them of great importance for the determination of the velocity of sound and the elasticity of solid bodies. The methods of measuring the velocity of sound in solids, which depended upon the perception by the ear of the unison of two notes were difficult in practice and gave imperfect results. Du Hamel* proposed to cause a pen attached to the rod to describe a wave line on a revolving glass plate, and thus to register vibrations; he did not carry the project into effect. Wertheim† in his excellent work em-

* Journal de Ecole Polytechnic Cohier, xxiii, 19.
† Pogg. Annalen, Ergänz., ii, 1.

ployed a method of this kind, and connected with the rod a chronographic apparatus. He determined the transverse vibrations of the rod by simultaneously registering those of a tuning fork, and then superimposed the longitudinal vibrations of the rod upon its transverse, and ascertained from the corrugated wave line thus produced, the relation between the longitudinal and transverse vibrations.

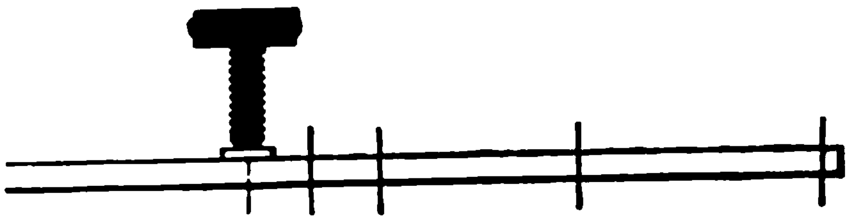
Kundt,* however, in 1866 contrived a method which is so well known as to need only a few words of description. A sounding rod is compelled to set into vibration a column of air enclosed in a glass tube, and in accordance with the laws of the organ pipes, the ratio of the length of the wave in the sounding rod to that of the wave of air in the glass tube, is obtained. Having corrected this for the temperature and the hygrometric state of the atmosphere it is possible to obtain a value for the velocity of propagation. During the past year, Kayser† employed Kundt's method for studying the ratio of the specific heat under a constant volume to the specific heat under a constant pressure.

1.



All of the above experiments were made upon metals. With the exception of MM. Wertheim and Chevandier's extended researches‡ upon the woods of the Vosga forests, I know of but very few determinations of the velocity of sound in wood. Having intended to measure the velocity of sound in some American woods, Kundt's method was first employed; the apparatus was similar to his but somewhat modified to suit the

2.



special circumstances. Fig. 1 shows the arrangement in perspective; B is the vise holding the rod, AC, clamped by a screw, O, acting on a plate of brass which presses the rod firmly upon its rest; the vise is screwed upon the table, which is fastened to the floor and braced to avoid shaking. The rod is rubbed by a resined woolen cloth along A, and being set into vibration,

* Pogg. Ann., cxxvii, 337. † Ibid., 1877, N. 10, p. 218.
‡ Comptes Rendus, xxiii, 663.

communicates it to the air in the glass tube, I, the dust figures then are formed at the nodes A, B, B′, B″, etc. The distances AB and B′ B″ are the semi-wave lengths of air corresponding to the note given by the rod. Although the length AB″ does not materially affect the length of the waves, it has been found best to make it equal to a multiple of the semi-wave lengths as then the figures are most definite. The glass tube was 1^{m}

TABLE I.

Name of wood.	No. rod.	Length.	Section.	Sp. Gr.
Cedar,	1	1836·0^{mm}	14·25 × 21·45^{mm}	·432
"	2	1838·4	14·15 × 21·45	·482
"	3	1838·75	15·6 × 20·45	·465
"	4	1836·72	14·3 × 21·6	·417
"	24	1650·0	14·3 × 21·1	·478
White wood,	5	1876·92	12·4 × 26·35	
"	6	1838·57	11·77 × 26·42	·476
"	7	1834·0	12·35 × 26·85	·443
"	8	1162·25	12·38 × 13·17	
"	9	1162·55	13·0 × 13·14	
"	10	1142·37	12·28 × 13·00	·478
"	11	1164·94	12·79 × 13·23	
"	12	1184·73	12·94 × 13·16	
White pine,	13	1842·6	17·86 × 21·27	·491
" "	15	1841·9	17·45 × 23·05	·432
Yellow "	23	1052·45	12·17 × 24·11	·664
Hickory,	14	1550·5	24·27 × 12·95	·922
White ash,	16	1836·5	9·55 × 19·65	·544
"	17	1838·26	9·55 × 19·70	·541
"	18	1809·7	14·98 × 17·6	·593
White holly,	19	1378·5	10·30 × 10·91	·562
Mahogany,	20	1349·1	11·54 × 11·52	·540
Black Walnut,	21	1378·63	10·82 × 9·73	·518
Cherry,	22	1560·1	10·92 × 11·49	·693
Red oak,	25	1494·7	12·35 × 18·28	·650
White oak,	26	1494·5	12·68 × 17·98	·775

Velocities obtained by Kundt's method.

TABLE II.

Rods.	Number of observations.	Temperature.	Velocity.	Probable error.
No. 1	25	15°·5 C.	3906·3 M.	2·4 M.
" 2	40	20·7	4027·6	8·08
" 3	25	16·1	3966·4	4·62
" 4	25	15·8	4071·68	9·90
" 5	25	13·5	5164·6	2·58
" 6	30	15·6	5129·9	12·29
" 7	35	16·3	5249·3	2·6
" 8	30	14·0	4912·31	4·3
" 9	35	14·4	4739·63	4·3
" 10	30	14·6	4712·53	2·4
" 11	25	14·5	5309·4	7·9
" 12	25	14·3	4845·17	3·4
" 13	35	15·4	4783·15	2·5
" 14	25	16·4	4110·07	2·1

long and 19^{mm} internal diameter; the cork H, inclusive of the two pins which held it to the rod, weighed 1·08 grams. With this apparatus the velocity of sound in the following woods was measured; cedar, white wood, yellow and white pine, hickory, white ash, holly, mahogany, black walnut, cherry and white oak.

The probable error is so small that it would seem to indicate either that the procedure is a very accurate one or that the error is constant and in the same direction.

But during the progress of these experiments, another method was devised whereby the rod registered its own vibrations. A blackened glass plate was drawn rapidly by in a horizontal direction by a falling weight, and matters were so arranged that a pen attached to the rod of wood wrote its vibration upon the plate, which simultaneously registered those of a tuning fork. The apparatus was capable of being leveled accurately, and it had connected with it an arrangement that enabled the observer to set it into action at any desired instant. The final result, of course, is that two parallel sets of curves are traced on the smoked glass. For the purpose of making the measurements it was necessary to compare the corresponding portions of the two curves, and two lines were drawn at right angles to them so as to include corresponding portions. This was effected by a little piece of apparatus especially contrived for the purpose. The number of waves registered were then counted with the aid of a compound microscope, which with its micrometer eye-piece was also used to measure the fractional parts of the waves. It was found possible with this arrangement to estimate, without any difficulty, the fiftieth part of a wave length. The following columns give ten readings of a single wave length, showing their agreement; the wave traced on the smoked glass, in this case, had an average length of $3·56^{mm}$.

3·57	3·58
3·60	3·55
3·58	3·42
3·70	3·30
3·52	——
3·75	3·56

For determining the rate of the fork, the average of six determinations of 5·033 seconds each, by a chronograph, was taken as follows: $\frac{7701·70}{6 \times 5·033} = 255·04$.

The difference between this quantity and the number of vibrations stamped on the fork by Kœnig (256) was due to the fact that the fork was loaded by the wax and pointer.

TABLE III.

Rods.	Kundt's Method.		Graphic Method.		Difference.
	Velocity V.	Probable Error.	Velocity V'.	Probable Error.	
1	3849·28 M.	2·5 M.	3785·3 M.	5·1 M.	64·0 M.
2	4061·56	2·79	4024.3	5·62	37·26
3	3934·49	4·35	3870.5	5·51	64·0
6	4985·05	10·30	4896.7	9·56	88·35
7	5278·59	9·69	5225.3	3·37	53·29
13	4753·02	2·88	4715.3	5·45	37·72
23	4326·36	2·14	4265.6	7·88	60·76
24	3950·90	3·66	3871.2	6·64	79·7

The first determinations were on the comparison between the graphic and Kundt's method. To this end an experiment was made by combining both methods, thus: while the rod was urging the air column into synchronous action by means of the cork (Kundt's method), it simultaneously registered, with its pen, the rate of its vibration. The results obtained by this double method should, of course, agree, as both the motions originate from the same source. They were found, however, to differ as shown in the annexed table.

These values are averages of fifteen observations. A glance at this table shows that the air method gives results which are invariably higher than the graphic method, the difference between the numbers being much larger than the sum of the errors in the two cases. This may be due to the fact of Kundt using too large a coëfficient for the correction for moisture and temperature. The experiments having been conducted during the winter, the amount of moisture in the laboratory was a minimum. Thus, calculating the velocities on the supposition that the air was perfectly dry we obtain the following results which are still too high.

Rods.	Calculated Velocity.	Diff. from Graphic Method.
1	3838·04 M.	+ 53·74 M.
2	4038 42	+ 14·12
3	3922·53	+ 52·03
6	4966·34	+ 69·64
7	5263·93	+ 38·63
13	4728·40	+ 13·10
23	4311·05	+ 45·45
24	3939·01	+ 67·81

These comparisons show, it would seem, that the tendency of Kundt's methods, at least as used by me, was to give results which were somewhat higher than they should have been.

To the above it may be added that in these experiments on Kundt's method, the stopper J, figure 1, was placed at a node, thus making an air column in the tube which was in unison

with the rod; the resistance to the rod's vibration was then small. But if we remove the stopper from the node and place it in the middle of a ventral segment, the resistance to vibration becomes a maximum, the rate of the rod is diminished and we have a lower number of vibrations actually executed and registered by the rod. Rod No. 23 was subjected to this test, its length being 1051·15mm. While the rod was urging the air column into vibration, the stopper being at a node, the rate of vibration registered by the rod itself was 2029 per second. Removing the stopper to a ventral segment diminished the rate to 2009·2 vibrations. In the latter determination no satisfactory dust figures could be obtained.

Having thus compared these two methods, we now proceed to give the results obtained by the graphic method upon the several rods. The rods were clamped in the center and without any load except the inappreciable weight of the pen.

TABLE IV.

Velocity of sound in American woods: measured by the Graphic Method.

Names of Wood.		Length.	Sp. Gr.	Temp.	Velocity.	Probable Error.
Cedar,	No. 1,	1836· mm	0·432	21·5 C.	3797·2 M.	3·56 M.
"	2,	1838·4	·482	20·9	4073·89	9·99
"	3,	1838·75	·465	28·4	3864·79	5·00
"	4,	1836·72	·417	---	4161·65	5·62
"	24,	1650·	·478	18·8	3915·47	5·89
White Wood,	6,	1838·57	·476	22·4	4927·30	7·43
" "	7,	1834·0	·443	19·8	5201·22	8·73
" "	10,	1142·37	·478	18·0	4650·60	3·90
" Pine,	13,	1842·6	·490	20·0	4713·36	6·63
" "	15,	1841·9	·432	20·0	4522·46	7·51
" Ash,	16,	1836·5	·544	27·0	4282·45	5·52
" "	17,	1838·26	·541	27·3	4261·51	5·88
" Holly,	19,	1378·5	·562	21·2	3657·41	4·95
Mahogany,	20,	1349·1	·540	20·0	4135·26	5·39
Black Walnut,	21,	1378·63	·518	19·1	4780·72	5·60
Cherry,	22,	1560·1	·693	18·0	4409·54	5·49
Yellow Pine,	23,	1052·45	·664	20·2	4274·48	5·60
Red Oak,	25,	1494·7	·650	25·0	4179·80	5·34
White Oak,	26,	1494·5	·775	25·0	4316·50	4·87

There were, however, certain difficulties to contend with which will now be briefly mentioned. I had not long been engaged upon this work, when I discovered a tendency to vertical transverse vibration in some of the rods, thus carrying the pointer off the plate. To meet this difficulty a kind of holder was contrived and covered with felt which, while only touching the rod lightly, held it in position. This damper was placed in various positions along the rod, and the corresponding rates of vibration measured. These values were tabulated for the several positions shown in fig. 2, which were as follows: E, as near the end as possible; D, 400mm from E; C, 700mm

rom E; B, as near the center as the clamp would allow. The esulting values given in the following table are averages of fteen observations.

TABLE V.

Showing the effect of the Damper.

Rods.	Damper at end.	At D.	At C.	At B.
No. 1,	3798·9 M.	3777·1 M.	3787·9 M.	3786·4 M.
" 2,	4063·7	4078·5	4062·7	4067·9
" 3,	3883·1	3872·0	3869·1	3865·0
" 6,	4876·8	4895·7	4840·7	4866·7
" 7,	5226·9	5205·0	5208·2	5213·7
" 13,	-----	4511·4	4517·6	4560·1
" 16,	4272·4	4244·4	4255·5	4259·3
" 17,	4259 1	4248·0	4256·0	4265·7

The results given in tables 2, 3 and 4 were obtained without he use of the damper.

It may be worth while to mention that some of the rods rhile vibrating longitudinally were capable of generating two otes, differing from each other by about a terz. These seemed o depend either upon some inherent condition of the wood or erhaps upon the relation between the two thicknesses and the ength of the rod. A little practice is requisite for bringing ut the lower note with sufficient power to cause it to be recog·nized and registered; it also required the exertion of a greater orce for its production and always preceded the high note. I lso found that the damper affected the high and low notes orrespondingly. The velocities corresponding to the high ote have already been given in tables 3, 4 and 5, while in able VI are the velocities deduced from the employment of he low note with rods 2 and 3 the damper being used.

TABLE VI.

Rods.	Damper at E.	At D.	At C.	At B.
No 2,	3637·6 M.	3663·2 M.	3663·6 M.	3704·7 M.
No. 3,	3643·87	3696·42	3677·12	3679·6

Subsequent investigation led me to the supposition of the oëxistence of transverse and longitudinal vibrations; the igher note being the normal note produced by longitudinal ibrations, the lower note being due to transverse motion.

In order to test this matter, the glass plate was caused by he falling weight to move in the direction of the length of the od, and it was found in point of fact, possible in this manner o register its transverse vibration. The number of transverse ibrations obtained for the high note were very nearly equal o the number of the longitudinal vibrations. The same rela·ion existed between the transverse and longitudinal vibrations

producing the low note. This is evident from the table given below:

TABLE VII.

Number of longitudinal and transverse vibrations corresponding to the high note.

Rods	Number of longitudinal vibrations in a second — N.	Number of transverse vibrations in a second — N'.	Difference.
No. 2,	1107·97	1068·29	38·68
" 13,	1227·21	1246·05	18·84
" 19,	1326·59	1333·75	7·16
" 20,	1532·60	------	----
" 21,	1733·89	1717·43	16·46
" 22,	1413·26	1391·80	11·46

TABLE VIII.

Number of longitudinal and transverse vibrations corresponding to the low note.

Rod.	Longitudinal — n.	Transverse — n'.	Difference.
No. 2,	1009·29	978·58	30·71
" 13,	998·58	976·14	22·44
" 19,	1167·62	1162·54	5·08
" 20,	1204·31	------	----
" 21,	1332·04	1211·71	120·33
" 22,	1115·66	1119·24	3·58

The only difference in the appearance of the longitudinal and transverse tracings of either of the notes was in their amplitudes. The high note possessed a larger amplitude in longitudinal vibration, the low note in transverse. If now we compare Tables VII and VIII, we find no harmonic interval embraced in the ratios between N and n, or N' and n', as is shown below; they however, in some cases approximate to a terz. Terz = 4 : 3.

TABLE IX.

Rod.	Ratio $\frac{n}{N}$.	Ratio $\frac{n'}{N'}$.	
No. 2,	1 : 0·9109	1 : 0·9161	secund = ·888.
" 13,	0·8137	0·7834	terz = ·8.
" 19,	0·8802	0·8701	secund = ·888.
" 20,	0·7858	-----	
" 21,	0·7682	0·7055	quart = ·75.
" 22,	0·7894	0·8041	terz ·8.

From the above experiments, we conclude; (1) That it is possible to measure the velocity of sound in rods with considerable accuracy by the graphic method; (2.) Kundt's method gives results which are slightly higher than those by the graphic method; (3.) The graphic method demonstrates the existence of transverse along with longitudinal vibration and gives their ratios.

Columbia College, Oct. 25th, 1877.

ART. XVI.—*The Relation of Secular Rock-disintegration to Lœss, Glacial Drift and Rock Basins;** by RAPHAEL PUMPELLY.

THE recent volume of Baron Richthofen's great work on China and Central Asia, is, to a considerable extent, occupied with a description of the great lœss formation and of the processes to which it owes its origin.

This remarkable formation covers several hundred thousand square miles in northern China, and larger areas in the rest of Asia. It forms the soil also over an immense area in the western United States. Its thickness varies, in China up to 2000 feet, and to 150 and 200 feet in Europe and America.

Lœss is a calcareous loam. It is easily crushed in the hand to an almost impalpable powder, and yet its consistency is such that it will support itself for many years in vertical cliffs 200 feet high. A close examination shows that it is filled with tubular pores branching downward like rootlets, and that these tubes are lined with carbonate of lime. It is to these that it owes its consistency and its vertical internal structure. It is wholly unstratified, and often where erosion has cut into it, whether one foot or one hundred yards, the walls are absolutely vertical. Its vertical internal structure causes it to break off in any vertical plane but in no other. Hence when a cliff is undermined the lœss breaks off in immense vertical plates leaving again a perpendicular wall.

It is divided into beds varying in thickness from one foot to two or three hundred which thin out to nothing at the borders and are separated by parting planes. These planes are marked by angular debris near the mountains, and by elongated upright calcareous concretions elsewhere.

This remarkable combination of softness with great strength and stability of exposed surfaces is of inestimable value in a woodless country. In Asia thousands of villages are excavated in the most systematic manner at the base of cliffs of lœss. Doors and windows pierced through the natural front give light and air to suites of rooms which are separated by natural walls, and plastered with a cement made from the lœss concretions. These are the comfortable dwellings of many millions of Chinese farmers, and correspond to the ruder "dugouts" of Nebraska.

To the same qualities is due the fact that the lœss districts of China are exceedingly fertile plains, in each of which a rapidly progressing erosion has excavated the most labyrinthine valley systems, in which all the members, down to the smallest tributaries, are sunk with vertical walls to depths of from one

* Read before the National Academy of Science, April 10th, 1878.

hundred to several hundred feet. Even the wagon roads become, in time, depressed to a depth of fifty feet and more by the removal of the dust by wind.

There is one more peculiarity of the loess—it not only is wholly unstratified, but it contains the remains of only land animals, and especially of land snails. Alexander Braun examined 211,968 specimens of shells from the loess of the Rhine between Basel and Bonn, and found that all were land snails except only thirty-three individuals, consisting of *Limnæa Planorbis* and *Vitrina*, which came from three isolated points in the valley of the Rhine and Neckar.

The loess, first well known in the valley of the Rhine and in France, was recognized later in other parts of Europe and in the Mississippi Valley. It was always looked upon as a subaqueous formation. Fourteen years ago I observed and afterward described some of the great loess-basins along the boundaries between China and Central Asia. I was lead to the conclusion, chiefly from topographical reasons, that the loess of these valleys had been deposited in a series of great lakes; and subsequent observers took the same view. But Richthofen, extending his fruitful journeyings over a wide area, found the loess occupying the loftiest passes of northeastern China, over 8,000 feet above the sea, and he proves, in the most conclusive manner, that an aqueous origin is impossible. For the former theories of loess formation which required inconceivable conditions and are full of contradictions, Richthofen substitutes an exceedingly simple and thoroughly consistent explanation. I hope I may be excused for giving it in brief terms:

Whenever, from any cause, the winds blowing toward an interior portion of a continent are drained of their moisture on the way, as by the elevation in their path of lofty condensing mountains, the region thus deprived of its rain-bringing clouds soon has its evaporation in excess of its rainfall. Its streams dry up; its soluble and insoluble products of disintegration are no longer carried to the ocean; the region becomes what Richthofen calls a central area, in contrast to peripheral regions which are drained directly into the ocean. The destruction of the vegetation lays bare the surface, and the products of disintegration are blown and sorted by the wind and washed by the occasional rains from the hills down into the valleys. This material is very nutritive and supports the grass of the steppes; the dust left by the winds and the hill-wash are arrested by the grass which they gradually bury while forming the soil for new growths. In this way, portions of the country become buried in their own and their neighbor's debris. Great thicknesses thus gradually accumulate undergoing a transformation into loess by the rootlets and stems of the vegetation. I will

ıark here that Richthofen has made known the fact that the ıs is the most fertile of soils, and that the grain-regions of thern China which have been continuously cultivated for re than 4,000 years require practically no manure but that y are self-fertilizing. This he ascribes partly to the porosity the material which causes it to absorb carbonic acid and monia in large amounts from the air; but more especially to elevation of nutritive salts in the capillary tubes by diffu-n whenever a rain establishes a moist communication between surface and the saline water below the drainage level.

Thus, whenever climatal changes have restored more or less isture to the atmosphere of a lœss district, we have in it the nost fertility. The cold and elevated regions of northern ina are the granary of the empire—and the seat of the pres- great famine.

Attention has been recently called by the German geologists the great fertility of the European lœss, and Professor Hay-ı has emphasized the fact that the abundant productiveness much of the West is due to the same soil.

Recognizing from personal observation the full identity of ıracter of the lœss of northern China, Europe and the Mis-ıri Valley, I am obliged to reject my own explanation of the gin of the Chinese deposits, and to believe with Richthofen ıt the true lœss, wherever it occurs, is a sub-aerial deposit, med in a dry central region, and that it owes its structure to formative influence of a steppe vegetation.

The one weak point of Richthofen's theory is in the evident ıdequacy of the current disintegration as a source of material. hen we consider the immense area covered by lœss to pths varying from 50 to 2,000 feet, and the fact that this is ly the very finest portion of the product of rock-destruction, d again that the accumulation represents only a very short riod of time, geologically speaking, surely we must seek a ore fertile source of supply than is furnished by the current composition of rock surface.

It seems to me that there are two important sources: I. The lt brought by rivers, many of them fed by the products of acial attrition flowing from the mountains into the central gion. Where the streams sink away, or where the lakes hich receive them have dried up, the finer products of the osion of a large territory are left to be removed in dust orms.

II. The second, and I believe, the more important source is the residuary products of a secular disintegration which we ll now consider.

In all regions where the soil is protected by a luxuriant vege-ion the greater part of the insoluble products of disintegra-

tion remains *in situ*. Considerable portions of the continents have remained above water during long geological periods. Where this has been the case, and where the region thus exposed enjoyed a peripheral climate with a protecting vegetation and abundant generation of carbonic acid, the feldspathic rocks have been profoundly affected; granite and gneisses being decomposed often to the depth of several hundred feet. In regions underlaid by impure limestones of great thickness, a long continued existence as dry land results in the removal of the lime carbonate and the formation of a residuary accumulation of the insoluble impurities. Thus in Missouri, in the Ozark Mountains, the secular dissolving away of the limestones which contained from two per cent to nine per cent of insoluble silica and clay has left such residuary deposits 20 to 120 feet thick.

The decay of a rock mass progresses from the joints and cracks, by which the mass is divided into polygonal blocks, and the rate of this progress varies, in different rocks, with the nature of the mineral constituents and the physical condition of structure, texture, mineral combination, etc.

In granular rocks, as granites, syenytes, gneisses, granulytes, diorytes, etc., the product is an argillaceous sand or a sandy clay; porphyries, basaltic, trachytic rocks, generally produce ferruginous clays; impure limestones and dolomites undergo the greatest shrinkage of volume, leaving masses of sandy clay with chert separating the broken up representatives of such layers of shales and sandstones as were interstratified with them. Calcareous sandstones and shales also leave sands and clays.

The decay may extend to great depths before it reaches the cores of the larger polygonal blocks. Where this is the case, the disintegrated mass consists of the rounded cores of the blocks surrounded by the decomposition product of the rest of the mass.

Other things being equal, the granular rocks of a region will be nearly or quite reduced to a loose mass when the compact rocks like porphyries and basalts have still a large proportion of their mass represented by the rounded cores.

Even slate rocks—especially talcose, chloritic, hydro-mica and sericite slates—are often affected to considerable depths.

As different rocks are affected in very different degrees by this change, it happens that in regions underlaid by a diversity of rocks, the plane marking the boundary between disintegrated rock and still hard rock must be an exceedingly irregular one.

If we could imagine the loose altered rock removed where this process has been active in depth, the surface exposed would present a remarkable topography, one in which the

ardness of the material would play no causative part. The rominent features, such as ridges and hills, would consist of ıe rocks that are most resistant to carbonic acid, as for instance, ıe soft clay slates and mica schists, as well as the hard quartz-tes and sandstones. The action of frost does not concern us ere, for it is comparatively a surface phenomenon.

The depressions would represent rocks more or less easily ɔted upon by carbonic acid, water and free oxygen, and to a reater or less extent, all rocks carrying a feldspar in abundance. Ve need not expect to find here inequalities of surface of the rpes produced by erosion. The depressions, instead of being alley systems caused by erosion by gravitating material, are ecessarily, to a great extent, closed basins produced by the ownward growth of the rock decay. Deep and shallow basins ithout outlets may be formed by the decay of the rock occu-ying the meshes of a network of less affected dykes or veins; ut generally they owe their origin to the unequal distribution f the sources of dissolving reagents on the surface above, for ıstance, swamps and lakes, and to inequalities in the character f the rock itself. On the other hand, dykes more easily ffected than the enclosing rock, and fissures causing the decay f their walls, would both give rise to remarkable defiles. 'hese conditions are all presented in the most striking manner n the plateau of Central Asia.*

* The importance of this decay in depth under protection from erosion seems to ıve wholly escaped the attention of geologists as a factor of general significance. ven the more remarkable local instances are rarely mentioned and only one or ro have found references in text books.

Mr. Darwin states that the numerous travelers in Brazil have all been surprised t the depth to which the gneiss and other granitic rocks as well as the talcose ates in the interior have been decomposed.

Near Rio every mineral except the quartz has been completely softened, in ɔme places to depths little less than one hundred feet.—Darwin, Geological 'bservations, Part III, p. 143. London, 1851.

Professor J. D. Whitney explains the accumulation, sometimes thirty feet thick f unstratified red clay, chert and galena in the Wisconsin lead region, by suppos-ng it to be the residuum left by the gradual dissolving away of several hundred eet of impure limestone.—Geology of Wisconsin, vol. i, p. 121. 1853.

I have since observed and described the results of this process on a much larger cale among the dolomites of southern Missouri.—Geological survey of Missouri; Iron Ores and Coal Fields, p. 8. 1873.

According to Dr. Benza, the Neilgherry Hills, occupying an area of about 700 quare miles in southern Hindostan are of granitic and hornblendic rock and are lisintegrated often to a depth of forty feet.—Leonhard u. Brown, Neues Jahrb. 'ür Min. Geol. u. Petrofact., 1838, p. 713.

The memoirs of the Geological Survey of India record the prevalence of this leep-seated decay in the crystalline rocks of that part of the world.

Dr. T. Sterry Hunt, who considers this decay to have taken place in Archæan ime, after affirming its prevalence and depths in the southeastern States, sees in the source of the extensive deposits of hydrated iron ores that occur along the ase of the Blue Ridge. He also ascribes its removal in the northern country ɔ the action of long-continued erosion and the final washing away by water and e during the Glacial epoch.—Proceedings Bost. Soc. of Nat. Hist., vol. xvi, Oct. 5th, 1873.

As soon as we pass the limits of glaciation we find in southern Pennsylvania, Maryland and Virginia the crystalline rocks profoundly affected, especially the feldspathic kinds, but the decay extends also, with differences in kind and degree to the various slates. It may be well seen in the railway cuttings in gneiss between Philadelphia and Baltimore, and in the slates of Frederick County, Maryland.

In the report of the geological survey of Missouri presented in April, 1873, I have called attention to the extent of this decomposition in the granites, porphyries, and limestones of Missouri, and to the great economic importance of its resulting accumulations which I have called residuary deposits in connection with the iron, lead and zinc ores.

In October of the same year, Dr. T. Sterry Hunt described the prevalence of this same decay throughout the southeastern States, often to a depth of one hundred feet or more, considering it to date from a very early geological time.

Over a large part of Europe and America this accumulation has been removed by glacial action. We may assume that during the gradual approach of the glacial epoch the ground in the northern half of the northern temperate zone, as the mean annual temperature fell below the freezing point, became perpetually frozen and when covered by the glacial ice, the thickness of the glacier instead of being measured from the upper surface down to the former soil should be measured down to the bottom of the residuary mass of disintegrated rock. It seems to me that only on this supposition can we explain the enormous amount of the ground moraine that covers our northern country, and the predominance in it of the debris of local rocks. The whole of this loose material must have participated in the movement of the ice, though far more slowly than the overlying and more nearly pure ice. Thus at any given point, the material on and near the surface would represent localities considerably farther northward than that at the bottom. We can only thus account for the disappearance of the vast amount of residuary disintegrated material that must have existed over the surface of the Archæan feldspathic rocks of eastern British America. But in Northern Asia, north of the 40th degree of latitude there are no traces of a general glacial action such as existed in Northeastern America and Northern Europe. The

According to a verbal communication of Professor W. B. Rogers, this deep-reaching decay is general throughout the schists of the Southeastern States, where its depth often exceeds two hundred feet.

Mr. Alexander Agassiz and Mr. Thomas MacFarlane have both informed me that, at least the granitic rocks of the Andes are similarly affected.

Since this paper was written, I have had occasion to observe the immense extent of the disintegration in place that exists in the slates, diorites and syenitic granites of the foot-hills of the Sierra Nevada in California.

evidence indeed is all the other way. And yet, while the rocks of Southern Asia show extensive residua of disintegration, the results of a secular decomposition protected from erosion by an abundant vegetation, the feldspathic rocks of Northern China and of Central Asia are as free from this as are those of north-eastern America.

The only answer to the question, what has become of them? is, that they have been blown and sifted and assorted by the winds, the heavier fragments remaining to be reduced by weathering and to form the stony steppes, the sand drifting in billowy waves over the country, and forming sand-deserts, while the fine dust floating in the air, an impalpable powder is deposited far and near, and, under the influence and protection of the steppe grasses, is transformed into the lœss.*

It is not many years since the glacial "till" was recognized as an extensive formation. The great development of the lœss has only just been demonstrated by the observations and generalizations of Baron Richthofen. The importance of each of these deposits seems to me to necessitate a recognition of the importance of the great residuary deposits as the source of both the others.

We have here suggestions that bear on many and varied geological problems, some of these which now occur to me I may be permitted to mention.

There are few problems in dynamical geology that have been considered more difficult to solve than the origin of rock-basins. Wherever my route between the great wall of China and the Siberian frontier lay through a region of crystalline rocks, I found that one of the characteristic features of the surface was the prevalence of basin-shaped depressions of all sizes hollowed

* No one can realize the capacity of wind as a transporter of fine material, who has not lived through at least one great storm on a desert. In such a simoon the atmosphere is filled with a driving mass of dust and sand which hides the country under a mantle of impenetrable darkness, and penetrates every fabric; it often destroys life by suffocation, and leaves in places a deposit several feet deep.

The prevailing westerly wind carrying sand, carves and polishes the rocky crest of the Sierra Nevadas, and, as Mr. King tells me, has formed long wind-stream deltas, if I may coin the term, in the form of lofty sand ranges stretching, from each pass eastward, far out on the desert.

The often-cited instances of far-driven volcanic ashes show the ability of the wind to carry comparatively coarse dust through distances of several hundred miles, but it does not seem improbable that the finer particles may remain suspended while the wind makes a complete circuit of the globe. I witnessed on March 31st and April 1st, in 1863, a dust fog at Nagasaki, which lasted two days, and left only a just perceptible film of dust, observable only on the white newly-painted deck of a yacht. A similar fog occurred simultaneously at Shanghae, and both were cotemporaneous with a terrific dust storm which during two days shrouded the country about Tientsin in deep darkness.

I am indebted again to Mr. Clarence King, for the statement that dust fogs occur on the coast of California with the prevailing west wind; and this may be as he suggests, the finest residuum of the lœss dust of an Asiatic dust storm.

out of the rock.* In other words, if filled with water they would have been lakes without outlets and with unbroken sides of rock. In some exceptional instances it was clear that systems of intersecting dykes had been less acted upon by the basin-making process than the intervening rocks, and the basins were formed in these last.

The rock basins of Scotland have been graphically described by Geikie, and while a great many of the countless lakes and lakelets in the region of the crystalline rocks of North America and Northern Europe are valleys of erosion with dams of glacial moraine material, vast numbers of them undoubtedly fill rock-basins. An ingenious explanation of the formation of these rock-bound depressions given by Ramsay and accepted by Geikie as the only reasonable hypothesis, is that the rock-basins of the loch and fiord kinds are due to unequal sculpturing by glaciers.

He says that where the bed of a glacier diminishes its angle of slope, the vertical pressure of the ice on its bed becomes greater, both owing to the lessened inclination and to the increased thickness of the ice, while farther down the incline the widening of the valley causes the ice to spread and consequently to diminish its thickness and pressure; the result being a rock-basin dammed by a rock-bar.

While this may be admitted, with some reservations, as a satisfactory explanation for many fiords and lochs cut in the declivities of a mountain range or of a steep coast, it is useless in regard to the lake-basins of flat countries, like Finland and British America. Geikie endeavors to use this hypothesis to explain also the rock-basins observed by me in Central Asia;† but it is still more useless here as an explanation, because there are absolutely no traces of glaciation in Central Asia, outside of the high mountain chains. These Asiatic depressions are rough and ragged, and the debris contained in them consists of ragged angular fragments of the local rocks, while the glaciated basins of America and Europe are smoothed and polished, and the debris they contain consists of the rounded and scored material of the drift.

The basins of Asia were emptied by wind, and those of Northern Europe and America were emptied by ice, but the wind and the ice were only immediate agents employed in rapidly emptying basins which had been long forming by a process common to both—the secular decay of the rock. I would thus seek the real cause, not in the unequal nature and action of the instrument, but in the unequal physical condition of the

* Pumpelly, Geological Researches in China, Mongolia and Japan, pages 72, 73, 26, Smithsonian Inst., 1866.

† Geikie—Great Ice Age, pages 351–352, D. Appleton & Co., 1875.

material operated on. It is evident, I think, that we have in these residua an adequate source of material for the glacial drift and for the lœss, although other sources have probably contributed in some regions to the formation of the latter, as for instance, rivers which, fed by silt-loaded glacier-streams, sink away on the plains of the central area, leaving their suspended material to dry and drift on the surface.

In reply to some questions bearing on the possible sources of the lœss of the Missouri valley, Mr. Clarence King kindly informs me that during the Pliocene the entire surface of the great plains was covered by a sheet of water which he has called Cheyenne Lake. Its deposits, known as the Missouri Pliocene—2,000 feet thick at the western edge along the Rocky Mountains—become very thin at the eastern margin in Kansas and Nebraska. Throughout the eastern portion at all points over 150 miles east of the mountains, the material is exceedingly fine—so fine that Professor Brewer found that when shaken with water in a test tube it does not settle after standing a year. Furthermore, Mr. King (anticipating one of the generalizations of the forthcoming volume of his reports), says that there was a period of intense dryness affecting the whole region of the great basin, and at least a portion of the great plains. During this period there were exposed to wind-erosion, not only the surface of the plains, but the entire region east and west of the mountains that had been subjected to the Bad-land erosion. The countless cliffs and rounded outlines sculptured out of the soft Tertiary clays and marls which form the Bad-lands were particularly susceptible to wind-erosion. Finally, Mr. King summarizes his answer in these words: "The lacustrine basins of the plains and Rocky Mountains certainly afford sufficient fine material, the period of desiccation between the two floods of the Quaternary affords the necessary dryness, and the prevalent west wind would account for the transportation to the east."

In the warmly contested question as to the capacity of continental glaciers in excavating solid rock, the great extent of the "till" and of the modified drift have been adduced as an evidence of this power. It seems to me rather that the abundance of the drift material may be equally well taken as in great part but not wholly a measure of the effect of long-continued and undisturbed disintegration and of the transporting power of ice, and that a period of glaciation may be, as Rutimeyer insists, a period of comparative rest as regards excavation of hard rock.

The great source from which mountain glaciers derive their moraines is, as is well known, in the incessant rending action of cold—of constantly alternating contraction and expansion—

on the rocks of the peaks and precipices that rise above the ice. But a continental glacier, such as covered Northeastern America, had no such source of supply: for all the mountains were covered with ice and were thus protected from the operation of this process.

The great ice-sheet removed the residuary accumulation of loose material down to the solid rock; in doing this the loose material was ground together, producing much clay and sand; and besides this, the glacier grinding with this material under the immense weight of the ice on the solid rock, exerted an abrading and polishing action, the product of which must have been wholly very fine flour. I would thus measure the excavating action of the continental glacier in solid rock only by a small portion of the finest part of the glacial debris. For, since all the bowlders of the ground moraine have been abraded over their whole surfaces, the amounts of the product of abrasion from the loose residuary material on one hand and from the solid rock bottom on the other should stand to each other in nearly the ratios of their respective surface areas.

Not the least important suggestion is the influence of the causes we have considered on the succession of marine strata. Great areas like Southern China and the southeastern United States have remained as dry land from the Triassic period till now. Throughout this long lapse of time, disintegration and decomposition have been at work, and one has only to look at the excavations in Philadelphia and on the railroads running south from there to get some idea of what these agencies can accomplish. But the abundant vegetation of a moist, peripheral region has so thoroughly protected the residuary mass from erosion that the streams run clear, carrying to the ocean only soluble salts and the comparatively unimportant products of attrition. There are three methods by which these vast stores of slowly-prepared detritus can become available to form mechanical sediments, and all are rapid, in this sense, viz: that other things being equal, by each method, the ocean receives in a given time an enormously greater amount of sediment than it would receive had there been no such accumulation ready at hand. The *first* method is an encroaching sea-coast. The *second* is the removal of the residua as the ground-moraine of a continental glacier to furnish the ocean-border with enormous quantities of gravel, sand and clay, both from the frontal moraine and through the immense influx of debris brought by the rivers, at first from the melting ice, and, for a long time afterward, from the accumulated masses of gravel and sand brought down by freshets. The *third* method is through the mediation of the lœss formation. Let us imagine a region of granites, gneisses and impure limestones that has long been

dry land, and has been covered by abundant vegetation, to be transformed into a dry, central area. The destruction of the protecting plants would expose to the fierce winds the loose residua of long periods of disintegration of the rocks. Under this process of a dry separation the material would be sorted, the finest carried to great distances, would find resting places only where under the protection of steppe grasses it could be fixed and transformed into lœss. The coarsest would remain to form the gravelly steppes, while the material of intermediate grain, chiefly siliceous sand, not capable of giving sustenance nor of being fixed, would drift in dune-like waves before the prevailing winds, transforming everything in its track into desert wastes.

We have in the immense lœss deposits of China, often more than one thousand feet thick, and in those of Europe and west of the Mississippi, which are often measured by hundreds of feet, the best evidence of the ability of the lœss-forming process to accumulate vast masses of fine material in a comparatively short time.

Let us now imagine this same region to be subjected to a reversal of this process, and transformed again into a transition zone, in the manner so strikingly described by Richthofen. As the rainfall gradually comes to balance and exceed the evaporation, the streams that empty into the ocean push their sources farther and farther back into the lœss territory, gradually tapping the Salt Lakes and taking up their tributaries until the ocean again drains the continent.

This is the period of the turbid waters. The rapid growth of systems of drainage and erosion in a lœss territory hardly admits of description. It is limited only by the amount of rain-fall. Coasts which during geological ages have received only limpid streams, and in whose waters the corals and lower organisms have worked heretofore, scarcely disturbed by the products of wave-erosion, are now continuously deluged with yellow silt.

The great silt-loaded rivers of the world are, in at least nearly all instances, streams which after running clear water for long ages, are now merely temporarily employed in making a rapid transfer of the lœss which is itself the product of a concentration by wind of the products of a slow disintegration which may have lasted from the Carboniferous period to the Post Tertiary.

When we consider not only the enormous volume of this silt, but also the fact that its extreme fineness causes it to be carried over great areas in suspension before it sinks, we can conceive that its effects may be catastrophic as regards the less plastic forms of life. This would be the case especially where

the range of a fauna peculiar to a given coast is more limited than the area affected by the silt. The waters of the China sea for one hundred miles or more out to sea are yellow at the surface with lœss-mud along six hundred miles of coast; and when we consider the extreme slowness of deposition of this fine material, we cannot doubt that below the surface the silt extends eastward to the Kurosiwa, and follows the lower strata of this current far to the northeast.

This rapid transfer will, sooner or later, bring all the lœss into the ocean, and thenceforth the waters of the streams and the coast will be clear, or alternately clear and turbid, in proportion to the absence or frequence of oscillations of the coast level.

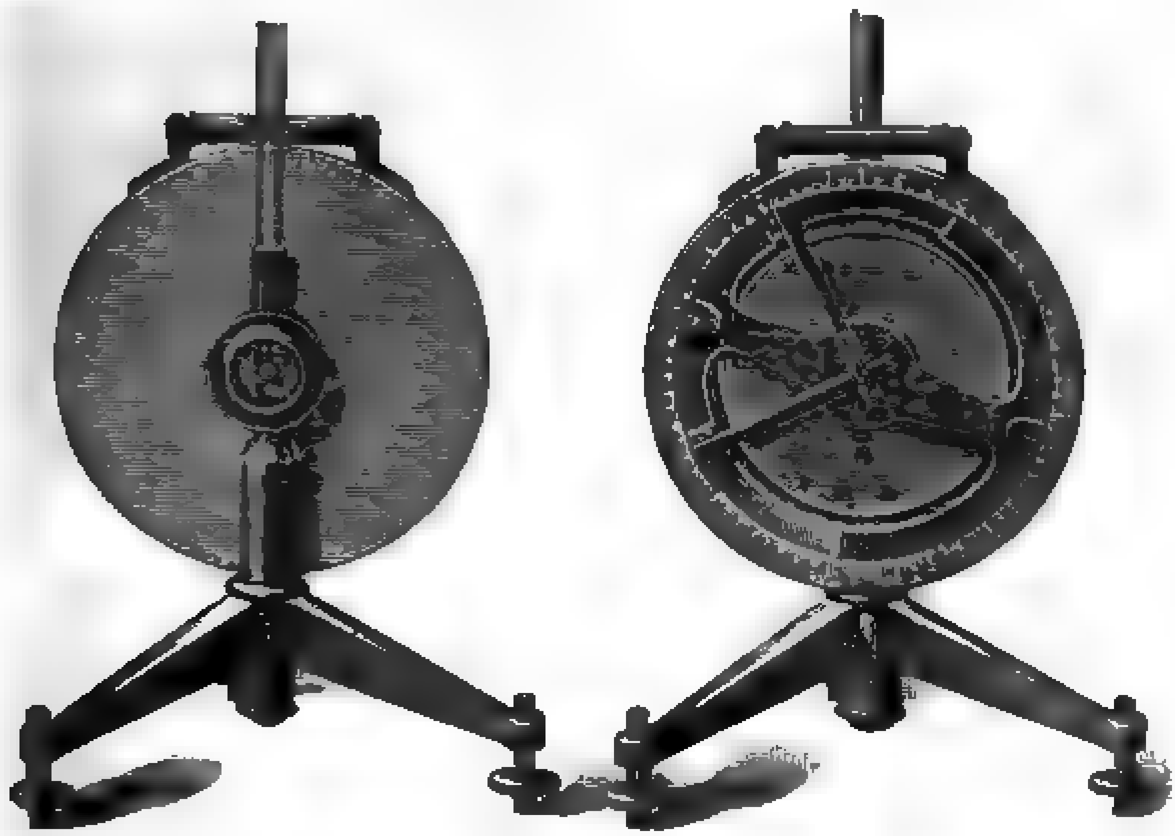
Environment and plasticity have been described as interregnant directing forces in evolution. It is during this period of turbid waters that the influence of environment and plasticity must be the most important factors in the evolution of life-forms; usurping, for a greater or less length of time, the position held for long ages by the purely biological factors—survival of the fittest, and heredity.

The very fine marine sediments are probably for the greater part the rapidly removed products of long-continued, protected disintegration and decomposition. If this be so, then the finer sand and clay rocks of any given column should record the extermination of all forms which, no matter how vigorous otherwise, were not able to adapt themselves to the radical change in their physical surroundings; and they should record also the operation of inorganic environment which then came in to break rudely the chain of descent, and introduce, during an interregnum, new laws of development under which grew up new forms.

In the removal of the residuary products of disintegration, glacial action and wind action perform parts that are nearly complementary to each other; for the removal by wind presupposes a central continental climate in which the dryness has temporarily become sufficiently extreme to destroy the vegetation, while a general glacial action presupposes a very moist climate.

ART. XVII.—*A method of Determining the Dip*; by N. D. C. HODGES.

THE magnetic polarity of a bar of soft iron is greatest when the bar lies in the line of the dip. This position of maximum intensity might be tested for by a small needle hung near one of the poles. This or similar ways have been used. The objections are that the rate of change in the polarity is small as the bar approaches the position sought, and the testing needle takes a less and less sensitive position, since the farther it is turned from the meridian the greater becomes the movement of the force of the earth upon it tending to bring it back. If, instead of one bar, two bars joined at right angles at a point near their ends be used, these difficulties may be avoided. When such a compound bar is placed so that the two branches make equal



angles with the line of dip, the effect on one of them is to make the lower end a north pole and its upper end a south, on the other the lower a south and upper a north. Supposing the bars exactly similar, the two poles at the point where they are joined, will neutralize one another; and any needle suspended near that point will hang in the meridian unaffected by the bars. A slight turning of the compound bar will render the field in which the needle hangs either a north or south, and it will move to correspond. To eliminate the effect of any permanent magnetism in the iron, four readings may be taken; first

both bars above the line of dip, then both below or in a position nearly 180° from the first, finally moving them so as to present the other side to the needle in each of the first two positions.

The first series of observations were made to see how constant the readings would be and how sensitive the method. They were all taken within twenty-four hours. After two of them the testing needle was changed from hanging horizontally to hanging at an angle of 45°. This was done to see if the poles at the outer ends of the bars had any influence. If the axis of the testing needle made equal angles with the two bars, the outer poles being at equal distances from the poles of the needle, would counteract each other as far as turning the needle. The results were constant within the limits of observation. The separate readings differed much more from the mean in the beginning. The bars seemed nearly free of permanent magnetism finally.

1st Series.

A,	77°·	77°·2	76°·7	75°·6	74°·5	73°·5	73°·1
B,	71·	70·7	70·6	71·6	72·7	73·8	74·2
C,	70·3	70·7	71·	71·8	73·	74·4	74·
D,	76·2	75·9	76·5	75·9	74·4	73·1	73·
Average,	73·6	73·6	73·7	73·7	73·7	73·7	73·6

The second series shows the effect of magnetizing one of the bars. The first three were taken in the morning, the last two in the afternoon, after the magnetizing. While the latter were being made, the magnetic state of the iron was rapidly changing, as the corresponding readings placed opposite one another show, and rendered any accuracy impossible.

2d Series.

70°·2	70°·5	69°·9	87°·5	84°.5
77·	76·4	76·1	57·5	60·8
76·9	77·2	76·4	72·	70·
70·3	70·1	70·5	79·5	80·
73·6	73·6	73·2	74·1	73·8

The third series gives the results obtained on trying to remove the magnetism by rapping the bars with a hammer after each determination. The separate readings approached the value of the inclination. The averages remained constant within the limits of the instrument.

3d Series.

84°·3	83°·2	80°·9	80°·2	80°·3
60·2	62·5	65·4	66·4	66·8
69·6	70·1	72·6	73·	72·4
81·	79·3	76·3	75·2	76·7
73·9	73·8	73·8	73·7	74·1?

The fourth series of results are those before and after heating the bars to redness for three or four hours.

4th Series.

Before heating.		After heating.				
66°·4	66°·2	67°·7	68°·4	68°·5	68°·9	68°·9
79·9	80·5	77·5	78·9	78·3	77·7	77·5
76·3	76·	79·1	78·7	78·2	78·6	78·6
72·1	72·2	70·	70·	70·1	70·1	70·
73·7	73·7	73·6	74·	73·8	73·8	73·75

The instrument used was constructed to test the principle of the method. The accompanying cut shows quite clearly the different parts. The views are of the front and back of the divided circle. The iron bars are shown in the position to the north and above the line of dip, the initial position of the above description. They are on a frame which turns about the center of the circle, and from which they can be easily detached and reversed. The other plan shows the testing magnet in the casing at the middle of the disk.

No particular care was taken to have the plane of the circle in the plane of the magnetic meridian. As a self-registering apparatus, the instrument seemed faulty; as at no time during the experiment did the magnetic state of the iron remain constant.

Physical Laboratory, Harvard College, Dec. 6, 1878.

ART. XVIII.—*On a Group of dissimilar Eruptive Rocks in Campton, New Hampshire*; by GEORGE W. HAWES.

AMONG other results of the petrographical studies made by me under the direction of the New Hampshire State Survey,* I have shown that the rocks of the dikes, abundantly scattered through the White Mountains, are very diverse in composition and in mineral constituents. Independently of the results of decomposition, which has in many cases widened original differences, rocks which to the eye appear identical are often found, on microscopic examination, to be fundamentally different; and the rocks of closely adjoining dikes not infrequently have nothing in common save their geological position. This feature is quite striking, especially when considered in connection with the uniform character of the eruptive rocks in some adjoining regions. To illustrate it I have made a study of a small group of dikes in Campton where this diversity is very well exhibited.

The Livermore Falls are in Campton, but they are only two

* Geology of New Hampshire, Hitchcock; Part IV; Mineralogy and Lithology.

miles distant from the larger and more accessible town of Plymouth. The Pemigewassett river has here cut a gorge through a hill, and in the walls of this gorge the eruptive dikes are very conspicuous. The gorge is not long, and the dikes, five in number, are all embraced in a portion of it which is little more than a hundred yards in length.

Attention was called to these dikes in 1837, by Professor O. P. Hubbard of Dartmouth College.* His description of them is accompanied by a picture of the gorge, which shows their forms and relative position; but as the rocks could only be identified by microscopic examination, he did not attempt to classify them.

The rock through which the dikes intrude is mica schist, which presents its usual diversities, caused by variation in the proportion of the essential ingredients and the presence of accessories. The strike is northeast and the dip is variable. These rocks are considered to be as old as the Silurian, and Professor Hitchcock regards them as still older.

The five dikes cut the schist almost at right angles; all are nearly vertical, and parallel to one another. A bridge has been built across the gorge from which all the dikes can be seen except the one directly under the bridge. From their position with reference to the schists, it is inferred that the fractures resulted from the action of the same forces acting in the same way. Yet among these five dikes, there are found four very well distinguished rock species. I will describe these rocks in the order in which they occur, beginning with the one highest up the stream.

Dike No. 1, is seen only upon the left of the stream. It is about three feet wide; the rock is black in color, compact and apparently nearly homogeneous. The study of some thin sections indicates that it is a *diabase.* It was originally a mixture of augite, a triclinic feldspar and titanic iron, but all its ingredients are partially altered. The augite is in process of alteration into hornblende; some of its grains being still intact, some being partially and others wholly altered. The feldspar is more or less changed, but shows its polysynthetic character throughout. The titanic iron oxide is extensively altered into the grayish white product that is called leucoxene. Minute apatite crystals are seen in the section. Calcite, as a decomposition product, fills cavities that are apparently made by the removal of some other mineral; these cavities are also often partially filled with analcite, which has a cubic cleavage and exerts a very feeble action upon polarized light. The analyses of all the rocks described are placed together on a subsequent page.

Dike No. 2 is eight feet wide. The rock is black in color,

* Am. Jour. Sci., I, vol. xxxiv, p. 105.

and is composed of a very fine almost homogeneous ground-mass, in which small black shining crystals are porphyritically developed. The thin sections indicate that this is *diorite.* It is a mixture of hornblende, a triclinic feldspar, and titanic iron oxide. The large crystals are of hornblende; it is here an original product, and has not resulted from the alteration of pyroxene, as in the last case, since its well-formed crystals are developed in the common hornblendic forms. Many of them are twin crystals, the twinning plane being as usual parallel to the orthopinacoid. Both the large porphyritic crystals and the small ones in the ground-mass are fresh and unaltered. The feldspar is in part fresh and in part somewhat altered. The basic nature of this rock, as of the last, indicates that the feldspar is a variety low in silica, but its species can not be determined by optical means. The iron oxide is quite abundant, and in part well crystallized. Sometimes a large opaque hexagonal section is met with which is probably menaccanite. The rock contains a little apatite. Calcite, some zeolitic, mineral of an undetermined species and a little chlorite exist as decomposition products.

Dike No. 3 is ten feet wide, and is filled with a massive rock fine in texture and white or grayish in color. When a section cut from a white specimen is examined, the rock is seen to be composed largely of small, quite well defined orthoclase crystals. The meeting of these forms angular corners, that are for the most part filled with lime and iron carbonates and chlorite, though some are filled with quartz. In sections from the darker specimens it becomes evident that the aggregate in the angles is a decomposition product, for remnants of a dichroic green mineral, which is probably hornblende, are left there. It contains in addition some magnetite and some specimens show a little pyrite. The rock is a very fine grained syenite similar to those which occur in different parts of the State.

Dike No. 4 is about a hundred feet from No. 3 but is identical with it in all respects. Dike No. 3 separates into two branches in the middle of the stream, and forms two dikes in an island there situated, and it is not improbable that No. 4 may unite with it at some point.

Dike No. 5 is about seventy-five feet from No. 4. It is very narrow, being only about a foot wide, but it has several branches as wide as itself which unite with it at acute angles. This again like No. 2 is composed of a fine grained ground-mass in which larger crystals are developed, but when the sections are examined it is found to be an *olivine diabase.* The porphyritic crystals are in part perfectly formed augite crystals, and in part well formed olivine crystals which are mostly changed to serpentine. The finer portion of the rock is com-

posed of augite, a triclinic feldspar, titanic iron and minute brown dichroic crystals of hornblende. Some small amygdaloidal cavities were observed containing sphærosiderite, calcite and analcite.

In these five closely adjoining dikes there are, therefore, four very different kinds of rocks. Selecting specimens as fresh as possible from the different dikes I analyzed them with the following results:—

	Diabase. Dike No. 1.	Olivine diabase. Dike No. 5.	Diorite. Dike No. 2.	Syenite. Dikes Nos. 3 & 4.
Silica	41·63	42·77	41·94	58·25
Alumina	13·26	14·06	15·36	18·22
Iron sesquioxide	3·19	2·72	3·27	1·07
Iron protoxide	9·92	8·34	9·89	5·96
Manganese protoxide	·27	·15	·25	·10
Titanium dioxide	3·95	2·35	4·15	*tr.*
Lime	8·86	11·47	9·47	1·51
Magnesia	7·31	9·72	5·01	*tr.*
Soda	2·49	1·89	5·15	4·19
Potash	3·32	1·43	·19	5·59
Carbon dioxide	5·20	1·62	2·47	4·75
Water	1·35	2·74	3·29	·85
	100·75	99·26	100·44	100·49

Though I have mentioned the existence of decomposition products, they are present only in minute quantities; and as in these very compact rocks the new compounds must have been formed from the old, I think the above analyses represent very nearly the original composition of the rocks, with, however, the addition of the water and the carbon dioxide.

Between the light and dark colored rocks there is a wide difference, which indicates that the reservoirs from which they were ejected contained fused material of very different compositions. The black rocks are nearly alike in composition, but their differences are such as might account for the variation in mineral constituents. The quantivalent proportion of the sesquioxides to the protoxides is considerably higher in the diorite than in the diabases, and this is a condition favorable to the formation of diorites, as shown by the higher percentage of alumina usually found in the hornblende of eruptive rocks. The larger percentage of magnesia may have favored the formation of olivine in one diabase and not in the other. But the presence of compact and porphyritic materials in different dikes, though of nearly the same composition, indicates different conditions of cooling and crystallization, and these may also have been a cause of the mineral distinctions.

In the adjoining Connecticut Valley the red sandstones are cut by numerous dikes. Many of these rocks and others geo-

ly related have been microscopically examined by E. S. and some were analyzed by myself † It was shown ese large dikes which are so characteristic of the Mesozoic ndstones of this coast are, wherever found, essentially n in composition and mineral constituents. They are ınds of labradorite, augite and magnetite, and vary only extent of their alteration. Professor Dana has concluded his uniformity and their wide distribution over the At-lope from Nova Scotia to North Carolina, that the dikes o profound depths.

most probable that the large and small dikes that are so n among the crystalline rocks of New Hampshire, occupy which were made during the elevation of the mountains. process of elevation, variable conditions must have been ıced in the strata at different places and times, on account conversion of mechanical work into heat, as has been by Mallet and others, and this would have modified the at which fused materials would be found beneath the . If partial crystallization took place before eruption, as case of many modern volcanic rocks, very variable con-might also have been introduced at different times for olidification. The Mesozoic sandstones referred to do cupy a position that indicates a great strain upon the crust at the time of fracture, but are found in areas of subsidence, and the uniformity in the dikes that charac-these regions, when compared with the diversity in the of the mountain region of New Hampshire, is as striking e contrast in the geological features of these two areas of n. A sinking of the earth's crust might result in pro-fractures which would reach to the homogeneous zone h the sedimentary formation. The crushing attendant elevation might fuse sedimentary deposits at various and produce fissures that would be filled with the iversified material.

XIX.—*Notes on the Mesozoic Strata of Virginia;* by Wm. M. Fontaine.

[Continued from page 39.]

ver Area.—This, the northern portion of the Richmond ows considerable differences from the Richmond coal The structure is not that of a basin, but it contains one e broad anticlinals, the beds on the west side dipping est against the Azoic, and on the east passing with a ıst and east dip under the Tertiary. We have here also ies. The lower has the general character of the lower

* This Journ., III, viii, 390. † Ibid, III, ix, 185.

series of the Richmond Coal field. It has no workable coal, and only a few thin and impure layers, at most, an inch or two in thickness. Plants occur, some of the species found in the Richmond coal field being discovered here also, with other, somewhat later types. Taken as a whole, this part of the belt contains, as Rogers long ago showed, strata somewhat younger than those of the productive portion of the belt lying farther south. Much of the vegetable matter seems to have been drifted into its present position. I observed a very curious patch of coal, very locally deposited, which seems formed entirely of the epidermal tissue of leaves, which have been drifted together and packed closely in layers. These leaves seem to have been principally those of *Macrotæniopteris magnifolia*. The upper series also presents a general character like that of the upper series of the Richmond coal field, but some of the peculiar features found in that field are here much more exaggerated. The exposures are very poor, and it is very difficult to make accurate examinations. The greater portion of this series is composed of sandstones with subordinate beds of shale. The sandstones of the uppermost portions, especially those found in the northern extremity of the tract, are remarkable for the unsorted and undecomposed character of the material composing them. This material is a mixture of quartz, pinkish feldspar and dark mica, easily recognized as coming from certain granitoid gneisses, which are found in force along the southwestern side of the area. On compression, this material forms a rock closely like the original gneiss. On the northwestern edge of the area, along the North Anna River, this finer matter has associated with it large, partly rounded stones, coming from the same granitoid gneiss. On this stream the stones make up the greater part of the mass. They are imbedded in a matrix of the above mentioned finer material. The stones are often quite fresh, and sometimes of very large size. I saw one granite bowlder ten feet through, and not fully exposed. Many are two, three, and four feet in diameter. I am not able to say what connection, if any, these stones have with the bowlders of the interior belts. They were deposited before the cessation of the emission of igneous matter, as they are penetrated by several trap dykes. They form certainly the youngest beds of the series. The dip is very obscure, but appears to be to the northwest. When these beds are traced to the eastern side of the area, where they pass under the Tertiary, we find that the number and size of the stones greatly decreases. The beds now take in fragments of the shale, and other strata of the lower series, which feature is never seen on the western side. This of course should be the case, if the eroding force acted from the west and southwest. These upper-

most beds pass, as it appears, up into the strata which occupy the border belts, and which here overlap, as stated before, this area. I have not seen any similar beds of stones, on the west side of the Richmond Coal field, and do not think that they exist there, though my observations are not extensive enough to decide the question positively. The lower and middle portions of the series are much like the upper series of the Richmond Coal field. They contain some thin films of coal, and some plants, too poorly preserved to be of much value in determining age, though so far as their evidence is to be taken, the series is certainly younger than the Richmond coal-bearing strata. A large amount of drifted vegetation, principally trunks and limbs of coniferous trees, now changed to lignite, or silicified, is found especially in the upper beds. The amount heaped up at certain horizons, is sufficient to give the appearance of small, locally developed coal seams.

The Fredericksburg Belt.—In this, also, we may recognize two series, a lower, about 150 feet thick, and an upper, still thicker. Both vary so much in the composition and structure of the beds, that it is difficult to give any correct idea of them without going into details, which would require too much space. The lower series, however, is more constant in composition, and may be generally recognized by its physical features, which is not the case with the upper. It is composed mainly of a curious sort of sandstone (Rogers' feldspathic sandstone) which possesses very little coherence. This is due to the fact that it is mainly composed of grains of sand, usually fine, surrounded by a non-plastic white earth, resembling kaolin. This is a composition which indicates that the sorting action of water has not been brought into play. This is farther indicated by the structure of the mass, which is usually affected with false bedding, and often resembles a mass of agglutinated sand. The planes of the false bedding are very short, and shift rapidly. The strata lie nearly horizontal, inclining slightly to the southeast. Small stones are often scattered through the mass, and beds, nests, or pockets, of larger stones, occur at different horizons. These stones are sometimes four to six inches in diameter. All the stones are either quartz, which is most abundant, or Potsdam quartzite. The lower portion is, on the whole, more siliceous and coarser. The upper part is often a fine-grained powdery mixture, of siliceous matter and kaolin, which shows very sudden changes of texture and a complicated cross-bedding. This material is very significant, as there is no rock in the Azoic of the adjacent country which could by its erosion yield it. The Azoic rocks to the west and northwest are mica slates, argillites, etc., which in decomposing yield yellow, reddish, and bluish clays, and yellowish or

reddish sand. From the character of the finer matter, a
its contained fragments, it is clear that much of it was d
from the Potsdam strata, on the west of the Blue Ridge
I shall have frequent occasion to refer to this Potsdam ma
a brief description of the occurrence and character of the
rocks will be required.

In my article on the "Primordial Strata of Virginia,'
lished in the May and June numbers of this Journal for
I gave some account of certain varieties of the Potsdam
which occur in great force near Rockfish Gap, on the
waters of South River, a branch of the Shenandoah Rive
at the entrance of the gorge cut by James River, at Ba
Falls, where it crosses the Blue Ridge. They also ar
posed along the entire lower course of the Shenandoah, a
the Potomac, a short distance above Harper's Ferry. A
latter place also, they are much crushed and fractured.
rocks, at these points, are much shattered, and lie in their or
beds so loosely, that they may be removed with a pick.
most notable of these rocks are compact, vitreous quartzit
peculiar sandstones, which have the grains of sand imb
in a white, non-plastic, argillaceous matter, like kaolin.
latter graduate, by loss of quartz grains, into shales or sl
a white color, composed of the non-plastic matter. A
strikingly white and void of ferruginous matter. It is
these strata that the Potsdam material comes, which is sca
so abundantly over portions of the eastern border of the At
slope, and this appears to be the source of the precisely s
white matter, which forms the finer material, of the lower
of the Fredericksburg Belt. As nothing like it is found a
the Azoic strata, fragments of this material may easi
recognized when found east of the Blue Ridge. Indeed
are as well characterized as fossils. Were there any
attending the assigning the source of these stones, from
cal evidence alone, to the Potsdam, it would be put at re
finding, as we often do, the well-known marks of *Sc
linearis* in these erratics. This lower series is best expos
the town of Fredericksburg, where it, in its more co
portions, yields a building stone, which was formerly
to a considerable extent.

The lower series passes up into a higher system of beds
stituting the upper series, which is marked by a smalle
portion of the white incoherent beds, so characteristic
lower, and by a predominance of clays of reddish, yell
and bluish colors, and of reddish and yellowish sands.
clays and sands increase in amount as we follow the belt
ward. Near Alexandria, between Washington and Balti
and near the latter city, they constitute the whole of the

es. The material of these beds comes from the decay of Azoic on the west. These clays and sands also are very gularly bedded. The sands especially, are much affected cross bedding. From Alexandria northward the lower es is rarely seen, being too deeply buried. At Baltimore ppears in the lowest white clays and sands dug in the base the hills. Toward the close of the formation of these strata y were invaded by some agent which planed them off, or red them more or less deeply into channels, and brought ng with it quantities of sand, gravel, large rounded stones slightly worn blocks, often of very large size. This matewas deposited in a confused manner, and is usually very erent from the beds on which it reposes. This agent seems ave acted from the northwest. From Fredericksburg to Potomac, the gravel and rounded stones are composed of rtz, Potsdam quartzite, and sandstone. In the vicinity Alexandria, Potsdam bowlders predominate over the quartz. ey are commonly six or eight inches in diameter, and often m the dimensions of one and two feet, showing frequently *lithus* markings. They are found over the surface of the ozoic here, five or six miles from the Potomac and up to Azoic border, often forming belts of stones packed in comuted Potsdam matter. Throughout the entire belt, the e, slightly worn blocks, are composed of crystalline rocks, n varying distances to the west and northwest, all the way he Blue Ridge. These are not rarely four or five feet in neter, and sometimes six or seven feet. Near Fredericksg, we may see large stones formed of the characteristic lotic and chloritic schists, composing the Blue Ridge on the t. Near Alexandria, large, slightly worn masses, having a neter of four or five feet, are found of the peculiar siliceous chloritic schists composing the Blue Ridge at Harper's ry, along with gneiss and mica schist from nearer localities. rth of the Potomac, over the lignitic and iron-ore clays, ween Washington and Baltimore, which belong to the upper es, I did not see any Potsdam material. The rounded nes and gravel are quartz, but the Azoic erratics abound. e iron-ore clays near the Relay House have been deeply red, and the excavations filled with coarse sand, gravel, sses of the iron-ore, and Azoic erratics. But this action s not seem to have been confined, in all places, to the er portion of the series. Near Neabsco Station, on the dericksburg and Alexandria Railroad, I found near the oic floor, and under a very considerable thickness of the er sands and clays, a heterogeneous mass of angular Azoic ter in large blocks mixed with worn and rounded stones, of rtz and Potsdam sandstone, imbedded in blue clay. This

drift matter, by the eroding and sorting action of the streams which cross it and pass into the Tertiary or Cretaceous areas, has been carried over to a distance, greater or less according to the particular conditions, on the surface of the more recent strata. It has by the same action been concentrated near the streams. Also in the space between these rivers, surface erosion and other causes have caused it to pass over a short distance on the newer beds, but it soon disappears within the areas occupied by such beds. In Virginia we have no means of determining whether the drift follows the surface of the upper series as it passes eastward under the Tertiary, but in Maryland it evidently passes eastward under the Cretaceous. Thus the wells bored to the southeast of Baltimore penetrate it on entering the clays and sands of the upper series. I have carefully examined the Maryland Reports for information on this head, and find that they give evidence that this bowlder deposit passes as far to the southeast as its horizon has been reached.

Fossil Plants.—These can be only briefly noticed. I have found a large number of well preserved plants at Fredericksburg in the lower series. They occur in a gray clay or shale, which rests on a bed of cobble-stones. I owe the discovery of the deposit to Professor P. R. Uhler, President of the Maryland Academy of Sciences. The material which imbeds the plants is not laminated, and the plants all seem to have been drifted. Considering their mode of occurrence, the small amount of change exhibited by some of them is wonderful. As the deposit is very local, it has hitherto escaped attention almost entirely. Many of the plants retain their entire structure, and are only colored brown. I have some which seem still to possess their chlorophyll! They have a decidedly green color. They are principally Conifers, Cycads and Ferns. No species of the Richmond Coal field are found here, but a few show affinities with Rhaetic plants. With the plants above named, I find certain netted-veined leaves, which by their nervation cannot be distinguished from Angiosperms. Had they been found with Cretaceous or Tertiary plants I think no one would hesitate to consider them as such. As, however, they occur with a well marked Upper Jurassic flora, I hesitate to pronounce them to be Angiospermous plants, without a more careful study and extended comparison, than I have as yet been able to make. They are certainly not "Dictyophyllum," which is the genus of fossil ferns that stands nearest to them. But when we find such a development of undoubted Angiosperms in the lowest Cretaceous beds of New Jersey and of the west, we should expect to find, at least, their ancestors in the Jurassic flora.

This flora, as a whole, is decidedly younger than that of the Richmond Coal field. Its rather complex type will require a

careful study to fix the age, but from my preliminary examination, I conclude that it is nearly of the age of the Upper Oolite of England, an age long ago assigned by Rogers to these beds. The general facies is much like that of the flora of Sutherland in Scotland, figured in part by Hugh Miller in his "Testimony of the Rocks," which he considered as being partly Liassic, but which Mr. Judd shows to be all Upper Oolite in age. R. C. Taylor found at another locality near Fredericksburg, but on the same horizon with mine, a few plants which he figured and described, in a communication published in the Trans. Geol. Soc. Penn., vol. i, 1835. These plants he considered to be Oolite in age.

In the upper series at Fredericksburg I have found, in a state of preservation permitting determination, only a few twigs of Conifers with leaves. But this series, both here and to the northward, is remarkable for the great quantity of lignite and jet which it contains, produced from the trunks and limbs of coniferous trees. The most abundant tree seems to have had a wood very like that of the white pine (*Pinus strobus*). To judge from the amount of this lignite in the upper series of the belt, the country must have been covered with extensive forests of coniferous trees, at the time of the formation of the beds composing it. The trunks are sometimes piled so thickly over each other that they produce the appearance of a prostrate forest. Near Neabsco Station we find such a state of things. The trunks are here flattened and imbedded in a blue clay. Great quantities of lignite occur in the clays of the upper series, especially the clays which Mr. Tyson calls "iron-ore clays," which are found between Washington and Baltimore. In these clays, stumps of Cycads, belonging to at least two new species of the genus *Cycadoidea*, are found. The blue clays at Baltimore yield some beautiful ferns of Wealden type. All the attainable evidence points strongly to the conclusion that the age of these upper beds is Wealden. Professor Rogers mentions that they yield at Fredericksburg two or three species of ferns and stumps of Cycads of the genus *Cycadoidea*. None of these have been seen by me. What the relation of these beds is to the lower clays of New Jersey with Angiospermous leaves, is not known, though, no doubt, the New Jersey beds are somewhat younger.

Professor Wm. B. Rogers has long held the opinion that these upper beds are Wealden in age. This is also the opinion of Professor P. R. Uhler. Mr. P. T. Tyson also held a similar belief which he based not only on the plants, but on certain fresh-water shells (Unios?) which resemble Wealden species. The beds in question, however, seem to be by all others considered as Lower Cretaceous, as it would appear, solely from their underlying known Cretaceous marine strata.

[To be continued.]

ART. XXI.—*Notices of Recent American Earthquakes.* N(
by Professor C. G. ROCKWOOD, Jr., College of New Jers

IN these notices, as heretofore, those based upon *single* n
paper notices and which could not be otherwise verified
printed in smaller type and the source of the informati
indicated.

For information received, I am again indebted to J
Batchelder, Esq., of Boston, who has kindly given me the be
of his lists; and to the U. S. Monthly Weather Review.

1877.—July 13. From Coban, a place in the central pa
Gautemala, east of the mountains, there were reported thi
or fourteen shocks at 5.15 A. M., the direction E. to W.—(
Weather Rev.)

From the same place are the following four.

July 20. At 10.05 A. M. two slight shocks, E. to W.

July 27. At 8 P. M. a slight shock, lasting a few seconc

Aug. 27. At 11.35 A. M. three shocks from the north.

Sept. 10. At 10.45 A. M. two shocks, lasting seven sec
and sufficiently strong to sway the façade of the church.

Sept. 10. A slight shock felt about 2 A. M. at Cambri
Mass. Eight hours later the shock occurred along the l
ware River, already noted, III, xv, p. 25.

Nov. 16. The shock about 2.30 A. M. at Knoxville, T
as noticed, III, xv, p. 27, was from S.W. to N.; and was
also at Murphy, N. C., where the direction was W. to E.
the duration fifteen seconds.

Nov. 21. At Coban, Gautemala, at 10.16 A. M. two ve
shocks, and at 10.37 P. M. a number of small shocks la
forty seconds.

Nov. 24. At Red Bluff, Cal., two shocks at 6.30 and
A. M., the first lasting twenty seconds, and being from E. t
This was felt also at San Francisco.

Nov. 26. At Coban, Gautemala, at 9.57 A. M. a few ve
shocks lasting twenty seconds.

Dec. 14. A strong shock at 7.15 P. M. in Callao, Peru, th
dulation being from N. to S.—(N. Y. Times.)

Dec. 18. At Beachburg, Ont., two shocks, the first bet
1 and 2 A. M., the second between 5 and 6 A. M. and quite se

1878.—Jan. 2. A slight shock about 7 P. M. in Louisa
Hanover Counties, Va., accompanied by a roaring sound.

Jan. 8. Two slight shocks at 10.30 P. M. at Cairo, Ill.

Jan. 23. At 7.55 P. M. a strong shock, lasting thirty sec
occurred on the southern coast of Peru. It was seve
Iquique and Arica, and was accompanied by a subterra

sound; but it was most destructive in the interior, where some houses were shaken down. But little damage was done on the coast; the sea was comparatively quiet and there was no tidal wave.

At Iquique lighter shocks followed with short intervals during the 24th and 25th, over *forty* distinct shocks being counted. A second heavy shock occurred at 8.30 P. M. of the 24th.

Jan. 27. The harbor of Callao was greatly disturbed by a ries of tidal waves. The heavy surf began about 3.30 A. M. d continued during the day, causing great damage to the cks and sea-wall, inundating the English railroad station and ulting in some loss of life. The movement came from the rth.

Feb. 5. A shock at 11.20 A. M. at Flushing, N. Y., sufficient to k windows.—(U. S. Weather Rev.)

Feb. 26.—A shock at 11.56 A. M. at San Francisco consisting of e vibrations N. to S., lasting five seconds.—(U. S. Weather v.)

Feb. 27. A severe earthquake occurred at 5 P. M. at Reykik and other places in the southwest part of Iceland. It was nected with a volcanic eruption which began the same night continued for more than a month. The new volcanic openi, fourteen in number, were situated in the Raudaskal valley, ut four miles northeast of Mt. Hekla.

March 12. At 4 A. M. a severe shock at Columbus, Ky., sing the fall of a portion of the bank of the Mississippi.

———. The same day two shocks at Milford, Vt.—(U. S. ather Rev.)

March 17. Two sharp shocks at St. Thomas, Lower California. U. S. Weather Rev.)

March 18. A slight shock at 6.30 A. M. at Tacoma, Washington er.—(U. S. Weather Rev.)

April —. "In the early part of the month," an earthquake occurred at Manizales, United States of Columbia, overthrowing a church tower.

April 12. About 8.40 P. M. a destructive earthquake occurred at Cua in Venezuela. This was a town of about 3,000 inhabitants, situated on the River Tuy, in N. lat. 10° 8′ 15″ and W. long. 66° 55′ from Greenwich, the center of a flourishing agricultural district. The height above the Caribbean Sea is 232 meters. The center of the town is situated on a small hill about 20 meters above the lower part. The hill is composed of gneiss, micaceous and chloritic schists, rising rather steep toward the W.S.W. It is surrounded by strata of clay and marl, covered by a deep stratum of alluvial soil, and resting on dark limestone and argillaceous schists. This upper town was

destroyed, being reduced to a heap of ruins in less than two seconds. About 300 lives were lost and property destroyed to the amount of £300,000. The lower town suffered very little. The direction of the shock was from E. 15° N. and the angle of emergence was found by A. Ernst of Caracas to be about 60°. The center could not have been very deep, as the destruction was limited to an area of one square mile. The transverse wave however was felt one hundred miles distant and occurred in Caracas, distant in a straight line twenty-six English miles, at $8^h\ 41^m\ 34^s$. Lighter shocks continued to be felt at intervals up to May 4.

For the greater part of the above I am indebted to an article by Mr. Ernst, in Nature, vol. xviii, p. 130.

April 15. At Glendive, Montana, on the Yellowstone River, there were three shocks, following each other at intervals of half an hour.

April 23. At Loreto, on the Gulf of California, a severe shock of two or three seconds at 10 A. M.; the first of a series lasting till May 3.—(U. S. Weather Rev.)

April 28. A severe shock, felt at Caracas at 8.30 P. M. destroyed a large part of the town of Ocumare, about twenty miles east of Cua and in the same valley.

April 29. Shocks were again felt at LaGuayra, Caracas, Porto Cabello and Valencia, in Venezuela.

May 8. At 8.25 P. M., a shock from N. to S. and sufficiently violent to stop clocks, was felt in the valley of the Sacramento Cal., from Red Bluff to Sacramento City, and also west of the Coast Range in Mendocino County.

May 14. A severe shock was felt at Guayaquil about 6.40 P. M., preceded by a loud noise. There was a less violent shock at 9 A. M. of the 15th.

May 15. A severe earthquake occurred at 8.35 P. M. at Tacna and Arica, Peru.

May 21. A shock at San Bernardino, Cal.—(U. S. Weather Rev.)

June 4. A light shock at 12.28 P. M. at San José, Costa Rica.

June 9. A strong shock at the same place at 4.34 P. M.

June 11. On the night of the 11th and 12th, four shocks were felt at Los Angeles, Cal., as follows; at 11.12 P. M. a distinct shock, at 11.20 P. M. a violent shock, duration five seconds, motion N.W. to S.E.; at 2.30 A. M. a light shock; and at 6.30 A. M. a slight tremble.—(U. S. Weather Rev.)

June 14. A slight shock at Cimarron, N. M.—(U. S. Weather Rev.)

July 2. Two light shocks at Campo, Cal., at $5^h\ 55^m\ 30^s$ (A. M. or P. M.?) from S.E. to N.W. with a noise resembling thunder.—(U. S. Weather Rev.)

July 11. A severe shock at midnight at St. Thomas, W. I.

July 16 and 18. Two severe shocks in Hayti.

July 21. A slight shock at 5 A. M. at Salt Lake City.—(U. S. Weather Rev.)

July 26. A slight shock, direction north and south, was felt at 8.25 A. M. at Los Angeles, Cal., and at San Gorgonio, San Bernardino and other places in the mountains east of Los Angeles.

July 27. At 7.30 P. M. a strong shock at San José, Costa Rica.

Aug. 3. A severe earthquake occurred at 2.15 P. M. in the Island of Martinique, W. I. The vibrations continued fifteen seconds, and in the town of Diamant several buildings were thrown down.

Aug. 9, 13, 14, 15, 22, 30. At San José, Costa Rica; on 9th at 4.15 A. M. a feeble shock; on 13th at 7.17 P. M. a strong shock, at 11.30 P. M. a feeble shock; on 14th at 3 A. M. and 12.48 P. M. feeble shocks; on 22d at 10 P. M. a strong shock; on 30th at 0.23 A. M. a feeble shock. At Cartago, twelve miles east of San José, five shocks occurred from 7 P. M of the 14th to 5 A. M. of the 15th.

Aug. 29. Letters from Alaska, dated Sept. 1, state that frequent shocks had occurred during the summer, in connection with renewed activity of the volcanoes of the Aleutian Islands. On Aug. 29, the village of Makuslin on Unalaska Island was destroyed by earthquake shocks and tidal waves.

Sept. 7. Three shocks from west to east at San Francisco about 9.35 A. M.—(U. S. Weather Rev.)

Sept. 24, 29. At San José, Costa Rica, feeble shocks at 5 A. M. and 6.55 P. M. of 24th, and at 7.45 A. M. and 7.15 P. M. of 29th.

Sept. 29th A shock about 6 P. M. at San Francisco and Oakland, Cal., from N.E. to S.W.

Oct. 2. At 6 P. M. a severe earthquake occurred in the southern part of San Salvador, Central America. The village of Jacuapa was nearly destroyed and much damage was done in neighboring places. The movement lasted over forty seconds and was from southwest to northeast. Eruptions were feared from the neighboring volcanoes, and advices a few days later report great activity in the volcanoes Izalco and Santa Ana.

———. The same day a slight shock was felt in Santiago de Cuba.—(U. S. Weather Rev.)

Oct. 4. At 2.30 A. M. a shock was felt along the Hudson River from Marlborough to Peekskill, N. Y., a distance of about twenty-five miles. It was sufficiently violent to awaken

persons and at some places was accompanied by a rumbling noise. The direction was north to south.

Oct. 9. A severe earthquake at Manizales, the capital of Antioquia, United States of Columbia, destroyed over a hundred houses, including the church, hospital and city buildings.

Oct. 11. At San José, Costa Rica, a feeble shock at 5 P. M.

——————. The same day at 7.30 P. M. a severe shock at San José, Cal., accompanied by a rumbling noise. The vibrations were north and south and lasted thirty seconds.—(U. S. Weather Rev.)

Oct. 21. At 5.40 P. M. two shocks from north to south at Sacramento, Cal.—(U. S. Weather Rev.)

Nov. 11. At 9.45 A. M. a slight shock from east to west at San Francisco.—(U. S. Weather Rev.)

Nov. 18. A shock was felt at St Louis, Cairo, Memphis, Little Rock and other places in the Mississippi Valley. The direction was generally north to south. The time was reported by the U. S. Signal Service observer at Cairo as $11^h\ 51^m\ 50^s$ P. M. He says, "a trembling was felt, lasting forty seconds, followed by a rocking motion from W.N.W. to E.S.E. lasting twenty seconds, and a second trembling lasting ten seconds." Another slight shock was felt at Cairo at 5.10 A. M. of the 19th, the direction of which was also W.N.W. to E.S.E.

Nov. 23. At Murphy, N. C., a slight shock at 10 A. M. from west to east, with a rumbling noise.—(U. S. Weather Rev.)

Princeton, N. J., Jan. 1, 1879.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Note on J. C. Draper's paper "On the presence of Dark Lines in the Solar Spectrum which correspond closely to the lines of the Spectrum of Oxygen."*—The paper above referred to appeared in the October number of this Journal. A cursory glance at it gives the impression that the methods had been carefully criticised beforehand, that the experiments had been made with minute accuracy and that the results were trustworthy; but closer examination of it raises most serious questions on all the points mentioned. Errors of method and of experiment appear which make it quite impossible to accept the conclusions reached. It is the purpose of this note to point out some of these.

In the first place the author throughout the paper confounds Ångström's scale numbers with wave lengths. Thus, for example, p. 257, he says, line 18, the photographs were "in sections of eighty to one hundred wave lengths," line 24, "each wave length being five millimeters in extent," and line 34, "each section of one hundred or more wave-lengths;" p.

258, line 24, "Error amounting to half a wave length could therefore exist in the position of a line, according as it fell on one side or the other of a figure on the scale expressing a wave length;" p. 259, line 18, one iron line "to every eleven wave lengths was used;" p. 261, line 18, no element gives "a line within two or three-tenths of a wave length of that position;" p. 264, line 16, "no other element furnishes a line which falls on the same wave length." In proof that he really means scale divisions, he gives a section of his chart on p. 259, and says, line 38, "On the first space below the line is the scale of wave lengths, each wave length being five millimeters in extent;" and p. 260, line 28, "in the eighteen wave lengths represented in the diagram." There are eighteen scale divisions in the diagram, each scale division being five millimeters long. Again, p. 264, referring to the coincidence of oxygen and solar lines in his table, he says, line 2, "in four, the difference is only five one-hundredths of a wave length; in twenty-two, ten one-hundredths of a wave length; in four, fifteen one-hundredths of a wave length; in eleven, twenty-one one-hundredths of a wave-length; and in the remainder, the greatest difference is only thirty-five one-hundredths of a wave length." Referring to the table, the four lines first mentioned are given as 3982·75, 4075·50, 4345·15 and 4483·80; the corresponding oxygen lines being given as 3982·70, 4075·45, 4345·20, and 4483·75. The difference is obviously five one hundredths of a scale division, not of a wave length. From the fact that this error runs through the entire paper, it would almost seem as if the author was not aware of the distinction between wave lengths and scale numbers. Using Ångström's scale he confuses wave lengths with ten millionths of a millimeter; whereas in the case of D for example, the wave length is nearly 6,000 times greater. If the author really means what he says, he asserts that the wave length of the mean ray of the spectrum is one two hundred and fifty-millionth of an inch instead of about one forty-thousandth, as we know it is.

Second, the author deems it of the greatest importance in the preparation of his solar photographs to use reflected rays exclusively; saying, p. 256, last line, "*at no time did the solar rays pass through glass*; all error that might arise during refraction was thus avoided." After this virtual condemnation of the use of refraction at all, he not only uses for comparison Ångström's wave lengths made with achromatic lenses and a refracting grating, constructing even his chart upon them as a basis, p. 258, line 7, "the values assigned to the wave lengths in this chart are those of Ångström;" but the very spectrum of oxygen by which the coincidences of the lines of this element with those of the sun spectrum were to be established, was photographed with glass prisms and achromatic lenses.

Third, the author states that the prisms with which the spectrum of oxygen was photographed were adjusted "to the minimum deviation of D'." Supposing D_1 to be meant, this

precaution, which gives the appearance of extraordinary accuracy to the adjustment, is practically an impossibility with the apparatus employed. Minimum deviation of the D line as a whole could not under these circumstances be distinguished from that of either of its components, nor could that of D_1 be distinguished from that of D_2. Moreover, it is difficult to understand why he adjusts to minimum deviation for D′ and not for G, near which the work is to be done. Instead of D′, the line for which his apparatus was adjusted should have been chosen in the photographic portion of the spectrum, for example between G and H.

Fourth, on page 265, line 25, the author says that this "is a problem not to be solved by the comparison of two spectra of small dispersion." Hence it is a matter of some surprise to find that in getting his oxygen spectrum, he uses only "two flint glass prisms of 60°" and for objectives, "achromatics of ten inches focus." The bright line spectrum of oxygen taken by Henry Draper, which the author in this paper inferentially attacks, was made, as we find on examination, with a direct vision battery of nine prisms and an observing telescope of forty-two inches focal length. The original negatives taken with the latter apparatus, must consequently have been eight or nine times as long as the author's; and even these were none too large for the proper solution of the question.

Fifth, the author seems to have attempted to compare together a diffraction spectrum of the sun with a prismatic spectrum of oxygen. Such a comparison, by the method adopted is manifestly of no value. Owing to the irrationality of dispersion of various refractive media it is an extremely difficult thing to compare accurately two prismatic spectra of different kinds. But the matter rises to an absurdity when a comparison is attempted between a grating spectrum and a prism spectrum. The graphic method, employed to supplement the direct method, does not appear to help the comparison, since the author nowhere gives both coördinates to the curve constructed.

Sixth, it is more than questionable whether the measurements of the solar spectrum lines actually made by the author are capable of the accuracy he assigns to them. The values in his table of wave-lengths are given to one hundredth of a division of Ångström's scale. As the author says on page 257 that each division of this scale, which is one millimeter, was enlarged to five millimeters upon the paper scale on which the photographs were projected, to measure to one hundredth of a scale-division would require the measurements on the screen to be made to one-twentieth of a millimeter or the one five-hundredth of an inch, about; a degree of refinement highly improbable under these conditions. Moreover the accuracy of the results of such measurements is seriously impaired by the variation in the position of the lines on the screen, due to the fact that the large number of negatives (eight or nine apparently), required to give the whole photographic spectrum, must, unless special precaution was taken (of which

there is no evidence), have been made with glass of different thicknesses. When projected in the lantern, this variation in thickness would necessitate a change in focus and so cause a change in the magnifying power. The smaller sizes of photographic glass vary in thickness from one to two millimeters. Consequently the displacement of the lines due to the difference of magnifying power arising from this cause would exceed considerably the limit of measurement, which, as above stated, was the one five-hundredth of an inch. But another and a more serious cause of inaccuracy must here be pointed out. From the data given by the author, it may readily be calculated that his original photographs of the oxygen spectrum, taken with two prisms of 60° and with lenses of ten inches focus, could not have been over half an inch long in the region from G to H. Since Ångström's chart from G to H is sixteen inches long, the author's spectrum would have to be magnified thirty-two times to make it the size of this. But as each millimeter of Ångström's scale was made five millimeters on the author's scale of measurement, the original negative as thrown on the screen must have been magnified one hundred and sixty diameters. Any one who has worked at all in spectrum photography, knows that it is utterly futile for purposes of measurement, to magnify a photograph taken under these circumstances, as much as this, since then the size of the silver grains becomes larger than the details of the picture. In the absence of any precise statement the reader has to make the calculation for himself; but the figures above given cannot be far astray.

Seventh, there is only an appearance of accuracy when the attempt is made to fix the position of the oxygen spectrum lines to hundredths of one of Ångström's scale divisions. The projection method by which the solar lines were measured, has already been proved inadequate. And as to the method of graphical interpolation, used as auxiliary to the lantern, it does not appear that as used by the author, it was capable of any such accuracy as that claimed. In constructing the curve, the iron lines are taken with Ångström's values for the wave-lengths; but these, though estimated to tenths were read only to whole divisions of the scale. Moreover, only forty-seven iron lines were used in all, or one to every eleven scale divisions; the reading being to one one-hundredth of a scale division, or 1,100 numbers to one iron line. Since the author measured no wave-lengths directly, he was obliged to construct a considerable " portion of the curve from the wave-lengths of oxygen and air lines already given by various authorities." These values were taken, page 258, from Watts' Index of Spectra. On referring to this book, the values are given only to the units place. And even then, discrepancies amounting to from three to five entire units, or from three hundred to five hundred times the author's limit, appear in the wave-length as given by the various authors relied on for the measurements employed in the paper before us.

Eighth, the author nowhere states the peculiar character of the lines in the oxygen spectrum and appears not to know that they have any. He has apparently taken it for granted that the lines of oxygen are intrinsically as sharp as the lines of the solar spectrum. But this, at least in many instances, is known not to be the case. Consequently it is quite impossible to measure the oxygen lines as accurately as the solar lines, and even these as has been shown cannot be measured to the accuracy which the author claims. Ångström himself admits that there may be an error of one-tenth of a division in his scale numbers.

It would seem sufficiently obvious from what has been said that the results given in this paper are entirely vitiated by the errors of method and of experiment which it contains. The author must not be confounded, because of the similarity of initials, with the distinguished investigator, Dr. J. W. Draper. G. F. B.

2. *On the Influence of Pressure on Chemical Action.*—BERTHELOT calls attention to the results of Pictet's experiments on the liquefaction of oxygen and hydrogen as illustrating his thermochemical views. The decomposition of potassium chlorate into oxygen and potassium chloride, as he has proved, is an exothermic reaction not limited by its inverse; hence it is not arrested by a pressure of 320 atmospheres. In fact the reaction $KClO_3 = KCl + O_3$, according to Berthelot's measures, evolves at the ordinary temperature 11 calories. About 400°, the chlorate being melted and the chloride solid, this quantity can only be increased. The same is true of the action of potassium hydrate upon the formate, the reaction by which Pictet prepared his hydrogen; the gas continuing to be evolved even under a pressure of over 600 atmospheres. This reaction is also exothermic and not limited by its inverse; the transformation represented by the equation

$$KCHO_2 + KOH = K_2CO_3 + H_2$$

evolving at the ordinary temperature 18·4 calories. At 400° or 500° all the bodies being supposed melted, the heat evolved would not be altered; because the heats of fusion of known salts do not exceed four calories and the initial system has two melted molecules, the final system has only one. Exothermic reactions then continue whatever be the pressure; but it is probable that their velocity is changed and perhaps the temperature at which they take place.—*Ann. Chim. Phys.*, V, xv, 149, Oct., 1878. G. F. B.

3. *On the Specific Heat and the Heat of Fusion of Gallium.*—BERTHELOT has determined the specific heat and the heat of fusion of gallium from an ingot weighing 34 grams, placed in his hands by Lecoq de Boisbaudran. The specific heat of this metal was determined in the author's water calorimeter, by the usual methods. Two experiments, made, the one between 119° and 30° the other between 106° and 12·5°, gave as the specific heat of liquid gallium (the melting point being 30°, but the state of surfusion continuing to near zero) 0·0802. The specific heat of solid gallium between 23° and 12°, was found to be 0·079. If the latter measurements be made too near the fusing point, the value obtained is too high.

The heat of fusion of gallium was determined by introducing a crystal into the surfused metal. The whole crystallized at once, and evolved heat which was measured. At 13°, the mean value for a unit of weight was 19·11 gram-degrees, the number remaining sensibly the same between 30° and 0°, because of the close agreement of the two specific heats. Referred to the atomic weight, 69·9, the heat of fusion is 1·33 kilogram-degrees or calories. The close correspondence of the two specific heats of gallium taken at nearly the same temperature, is true also of mercury, lead, tin and bismuth. The atomic heat of gallium in the liquid state is $69·9 \times 0·0802 = 5·59$; in the solid $69·9 \times 0·079 = 5·52$.—*Ann. Chim. Phys.*, V, xv, 242, Oct., 1878. G. F. B.

4. *On the Occurrence of Ytterbia in Sipylite.*—The mineral called sipylite was described by MALLET as a new niobate, as occurring in Amherst county, Virginia, associated with allanite.* An analysis was made of it by Brown in his laboratory, who found that, among other things, it contained 28 per cent of earths supposed to be erbia and yttria in the ratio of 27 to 1. At the request of DELAFONTAINE, a portion of this mixture of earths was sent to him by Mallet. Its pale yellow color indicated to him the presence of terbia or philippia, if not of both. But the feebleness of its absorption spectrum, and the very weak rose color of its nitrate and oxalate led him to believe that if no error had been made in determining the atomic weight, a new metal was present. The quantity of material being too small to decide the question, he succeeded in separating some sipylite from some allanite in his possession. From this a pale yellow earth was obtained, the nitrate of which showed in the spectroscope small quantities of erbia and philippia. But the high atomic weight 127 or 128, taken together with the weakness of its spectrum, indicated that the earth was new. By several partial decompositions of the nitrate, a feebly colored base was obtained, having an atomic weight near 134, giving colorless salts, yielding a sulphate like that of yttria, and crystallizing easily, a formate crystallizing in mamillated masses, and a double sulphate with potassium easily soluble in a concentrated solution of potassium sulphate. While he was looking for a name for the new earth, the description of Marignac's ytterbia appeared, the characteristics of which accord so well with that of his new earth as to leave no doubt of their identity. The discrepancy in atomic weight will be settled by new determinations.—*C. R.*, lxxxvii, 933, Dec., 1878. G. F. B.

5. *Upon the development of Electricity as the equivalent of chemical processes.*—In this paper H. F. BRAUN discusses the equivalence of heat and work, and electricity developed by heat and work. Some of his conclusions bear directly upon the question of dynamo-electric machines. He proves that with electricity of high tension, the per cent of potential electric energy which is converted into work is less, the greater, under like conditions, the tension is: That heat never can be wholly converted into electricity;

* This Journal, III, xiv, 397, Nov., 1877.

but only to the same degree to which it can be also converted into work.

If placing the three quantities in this order: (1) Electrical potential energy; (2) Mechanical work; (3) Heat. We have: 1 can be entirely transformed into 2 and into 3; 2 can be entirely changed into 3 but only partly into 1; 3 in general, can never be entirely transformed into 2 or into 1. The remainder of the paper contains the application of the foregoing laws to the theory of the Voltaic cell.—*Wiedeman's Ann. der Physik und Chemie*, 1878, No. 10, p. 182. J. T.

II. Geology and Mineralogy.

1. *The Lœss of Minnesota;* by N. H. Winchell. The following facts are taken from the Sixth Annual Report (for the year 1877) of the Geological and Natural History Survey of Minnesota, under Professor N. H. Winchell.—That the lœss deposit is the result of widespread diffusion of fresh water, at the time of the last Glacial epoch over those surfaces either drift-covered or not, which were not at the time affected by the glacier movement, is highly probable; but what the peculiar circumstances and causes of such gentle diffusion of nearly tranquil waters were, it is not yet possible satisfactorily to detail. The lœss is found in all parts of Ramsey County, but it varies in thickness and in composition. It is thin or wholly wanting in some rolling gravelly tracts, and is very thick in some confined valleys. It is sandy, or graduates downward into sand, in much of the northern part of the county, particularly in Rice Creek valley, and in some places in the bluffs of the Mississippi below St. Paul, and it is fine and somewhat clayey in the high and rolling clay tract in the eastern part of the county, particularly in the eastern part of New Canada. It forms a very fine soil for farm crops. It covers the bowlders and gravelly clay of the real drift. It fills some old valleys—indeed is always thicker in valleys than on the uplands. It is occasionally stratified and passes into sand below in places where agitated water was abundant enough to have moved such materials before the epoch of the loam. In other cases it is placed abruptly immediately over a coarse, gravelly or bowlder-bearing stratum.

In the southwestern corner of the State (Rock and Pipestone Counties) there is a gradual change from stony bowlder-clay to lœss, horizontally, in passing from the Coteau de Prairie (in Lyon and Murray Counties) southward to the Iowa State line. Exposures along the banks of creeks, and the digging of wells, make this plain. There is a gradual loss of bowlders, then of the small stones, then of gravel; and an equally gradual increase of the characteristic features of the lœss,—close, clayey consistency, crumbling in the air like slacking quicklime, and white limy concretions, in some cases the concretions which have been so often mentioned as a peculiarity of

the lœss, are in the same deposit with small gravel stones of northern origin; and pieces of northern limestone. The drift clay, true northern bowlder clay, the product of glaciers, thus changes gradually into a true lœss, the product of aqueous agencies. While this indicates for that locality, at least, a merging of one force into the other, and the slowness of the change, through an interval of about fifty miles in a broad, level, open country, it perhaps gives the key to the events that occurred in other latitudes where the surface was more broken, and where the effects are more complicated by not having all the steps recorded. Just as in the older geological formations, wherever the series is complete, without sudden transitions, the history is best known, so in the history of the drift, where the effects change gradually, are the records of "lost" epochs, and these "beds of transition" need the closest scrutiny, being the only evidence of what transpired between formations which in other regions pass abruptly from one to the other. This here indicates that the age of the lœss was cotemporary with that of the bowlder clay in the Coteau de Prairie. There must be some explanation given for the coëxistence of these forces which spread the loam and those which brought the glacial dirft. In other words, if the loam, which is sometimes a laminated clay, be regarded as the equivalent in age of the fine laminated clays of the great lakes and of other high-water marks in the northwest, which have been referred to a distinct "epoch" by Dana and others (the Champlain), then that epoch was not subsequent in time to the Glacial epoch but cotemporary with it, and its phenomena differ from those of the last Glacial epoch because they have been studied at distant points where they are contrasted, and where the glacial winter operated differently. Where there is an immediate succession of superposition, that fact in the drift does not imply immediate succession in time any more than it does in the Silurian rocks, a fact which has been ignored many times; and hence have resulted a great many special histories and theories. The lœss, for instance, lies on the older drift clay all along the Mississippi valley, and has generally been taken to prove an immediate transition from the drift-epoch to the loam-epoch, when really a long period of time, involving forest growths and the slow on-coming of a Glacial epoch, intervened, the loam itself passing horizontally into the glacial deposits of that epoch.

So in Ramsey County the loam has been seen to follow by insensible gradations from a sand or even a fine gravel, the change here taking place perpendicularly. In this case the coarser deposit below was the result of more copious and more agitated water, as in the bluff-terraces below St. Paul, or in the washed materials in the western part of Reserve township, and the loam the result of the diminution and more quiet state of the same waters. Thus, if the waters which overspread and washed the old drift and formed the gravelly terraces of the Mississippi came from the ice-fields of a contemporary glacier lying further north,

then the waters which spread the loam, a finer deposit, also came from the same source, operating a little later, and with diminished force.

2. *Systematic Geology of the 40th Parallel;* by CLARENCE KING.*—The following are citations from one of the chapters in this valuable volume; it is entitled "Résumé of Stratigraphical Geology," and gives some of the geological conclusions reached by the author.

In the 120,000 feet of sedimentary accumulations the grander divisions of Archæan or Azoic, Palæozoic, Mesozoic, and Cenozoic are distinctly outlined by divisional periods of marked unconformity. Considered as a whole, there is a noteworthy fullness in the geological column. None of the important stratigraphical time-divisions are wanting except those obscure intermediate deposits which in other countries lie between the base of the Cambrian and the summit of the crystalline Archæan series. From the first of Cambrian age to the present every important interval of time is recorded in the abundant gathering of sediments, which are with singular fullness characterized by appropriate and typical life-forms.

As in all other geological fields, the most important interruption of the continuity of deposit was at the close of the Archæan age, and the most striking difference between any two successive groups of rocks is that which characterizes the relations of the Archæan and the Palæozoic. With the exception of a few slates of supposed Huronian age, which the microscope shows to be richly charged with crystallites, all the non-eruptive Archæan rocks have passed from the original condition of detrital beds into sheets or bodies of distinctly crystallized material.

Not only are the Archæan exposures of such frequency over the Fortieth Parallel area as to insure a moderately complete knowledge of stratigraphical sequence and materials of the period, but also, owing to the relations which have been described with the overlying Palæozoic, I am able to reconstruct with considerable accuracy the topographical configuration of the Archæan surface. Supposing all the post-Archæan rocks to be removed, and considering what we now know of the whole area at the close of the Archæan age, the first prominent fact is, that coëxtensive with the greater part of the Cordilleras—that is, from longitude 104° westward as far as the Archæan exposures extend—was a great Archæan mountain system built up of at least two sets of nonconformable strata, referred to Laurentian and Huronian; the lower and older composed of granitoid gneisses chiefly made up of quartz and orthoclase, but carrying a little mica, sparing triclinic feldspars, and chlorite pseudomorphous after garnet and mica.

Over these, whether with actual conformity or not is undetermined, lies an enormous series of mica gneisses rich in quartz and biotite, orthoclase ordinarily exceeding plagioclase. The earlier aplitic gneisses and the later mica gneisses expose about 25,000 feet each of conformable beds.

* See the preceding number of this Journal, page 66.

A third group, nonconformable with the earliest aplitic series, the relations with the intermediate mica-gneiss series being unknown, consists of mica and hornblende schists passing upward into slates, quartzites, limestones, and dolomites. * * *

Upon grounds set forth in Section IV of Chapter II it is clear that the general topography prior to the deposition of the earliest Cambrian rocks was that of a great mountain system, displaying lofty ranges made of crumpled strata, enormous precipices, a result of mechanical dislocation, and, finally, a type of high mountain sculpture of such broad, smooth forms as to warrant the belief that subaërial erosion had never carved and furrowed the mountain flanks with the sharp ravines characteristic of modern mountain topography. East of the Rocky Mountains, in the geological province of the Great Plains, there are no Archæan outcrops; and when we consider the comparative thinness of the later sedimentary beds superposed over that region, the absence of outcropping Archæan masses piercing through the latter sediments is excellent proof that over that area Archæan mountain ranges did not exist. This is important as defining the Archæan Cordilleras within the limits of the modern Cordilleras, or, as is a more strictly correct view, the Archæan Cordilleras have determined not only the general area but much of the local detailed structure of the modern Cordilleras.

The topographical features of the present terrestrial surface are far less grand than the Archæan orography. The great Archæan precipices brought to light in Uinta and Wahsatch ranges are absolutely unparalleled in the topography of to-day. * * *

There is always a complete, sharp, unmistakable nonconformity between the crystalline Archæan topography and the superjacent sediments.

Considered as a whole, the Palæozoic series constituted a conformable body, laid down over the rugged Archæan mountain system. It first appears in the region of the Rocky Mountains with a total thickness of about a thousand feet, the strata surrounding and abutting against permanent Archæan islands, which, during the whole Palæozoic and Mesozoic, were lifted above the level of deposition. Throughout all Palæozoic time only 1,000 feet of strata accumulated over our part of the Rocky Mountains, and we get no glimpses of deeper hollows in which lower Cambrian beds might have been deposited. Passing westward, the series gradually thickens to 32,000 feet in the region of the Wahsatch and about 40,000 feet at the extreme western Palæozoic limit, longitude 117° 30′, where, from the evidences of shore-phenomena, and the non-continuation of the beds westward, we are warranted in assuming the Palæozoic coast. * * *

Viewed regardless of the age of the individual beds, the Palæozoic series can be divided by the character of their materials into four great groups. The first is a purely detrital Cambrian, which, although of comparatively fine sediments, in the presence of occasional conglomerates gives evidence of repeated subsidence.

The second group is the great limestone series, beginning with the Pogonip Cambrian limestone, and extending upward to the top of the Lower Coal Measures for 11,000 feet, only interrupted, in the horizon of the Lower Devonian, by a sheet, from 1,000 to 2,000 feet thick, of fine quartzitic detritus. This enormous group of 11,000 feet of limestone, characterized by abundant pelagic faunæ ranging from the Primordial to the top of the Lower Coal Measures, represents in general an age of deep seas. * * *

At the close of the deep-sea lime-period came a third great stratigraphical division of the Palæozoic — Weber quartzite — a body of pure siliceous detritus from 6,000 to 10,000 feet in thickness, characterized by conglomerates both in the near neighborhood of the granitic islands and close to the Nevada shore.

This is immediately succeeded by the fourth group or Upper Coal Measure limestone, a body about 2,000 feet thick of strictly pelagic material.

The whole Palæozoic, therefore, may be summed up as to its material as two periods of mechanical detritus, interrupted by one and followed by another period of deep-sea lime-formation. While in the conglomerates which appear in all the siliceous members of the series we have evidence of episodes of shallow waters, yet the occurrence of 13,000 feet of limestone indicates enormous intervals of the continued sway of profound ocean. * *

After the close of this great conformable Palæozoic deposition, wide-spread mechanical disturbance occurred, by which the land area west of the Nevada Palæozoic shore became depressed, while all the thickest part of the Palæozoic deposits from the Nevada shore eastward to and including the Wahsatch, rose above the ocean and became a land area. Between the new continent and the old one which went down to the west, there was a complete change of condition. The land became ocean; the ocean became land. In the rising of the Palæozoic, however, the elevation proceeded no farther eastward than the Wahsatch. East of that point, the Upper Carboniferous beds were still the undisturbed ocean-bottom; but instead of receiving sediments either from the destruction of organic life within the ocean area or from the distant continental sources to the west, the newly elevated land-mass, extending from the Wahsatch west to 117° 30′, became the area from which was derived the post-Carboniferous detritus to form the great Mesozoic series that, east of the Wahsatch, were laid down conformably upon the still submerged and still undisturbed Carboniferous.

Upon the western side of the new land-mass, the Archæan continent, having gone down, made a new ocean-bottom, and upon this immediately began to accumulate all the disintegration-products of the new land-mass which the westward draining rivers and the ocean waves were able to deliver. Throughout the Triassic and Jurassic periods the western ocean was accumulating its enormously thick group of conformable sediments upon an Archæan floor, while east of the Wahsatch, in the mediterranean ocean, the

sediments of the Trias and Jura were accumulating conformably upon the Carboniferous; until, at the close of the Jurassic age, there had accumulated in the western sea 20,000 feet, and in the mediterranean sea 3,800 feet, of Triassic and Jurassic material.

The comparison of the Trias-Jura series, in these two separated seas, shows two things: first, that the western sea was very deep during the Trias; secondly, that the mediterranean was shallow during the Trias. * * *

At the close of the Jurassic age, the western ocean, with its original floor of Archæan ranges overlaid by twenty thousand feet or more of conformable Trias-Jura sediments, suffered abrupt orographical uplift, resulting in the formation of a series of sharp folds and elevating a portion of the ocean area, extending from the eastern shore outward and westward as far as the present west base of the Sierra Nevada, making an addition to the continent of 200 miles, the Sierra itself constituting the most western and most elevated of the newly formed mountain ranges. * * *

While this powerful dynamic action was taking place on the west side of the land area, there still remained, so far as upheaval, subsidence, or folding is concerned, a complete calm in the region east of the Wahsatch. The uppermost shaly members of the Jurassic from the Wahsatch out to Kansas are immediately conformably overlaid by the basal members of the Cretaceous. * * *

During Cretaceous time the mediterranean ocean stretched from the eastern base of the Wahsatch into Kansas; and over the entire bottom of that body of water, with the exception of a few Archæan islands, which were still, as they had been throughout the previous ages since the beginning of the Cambrian, lifted above the plane of deposition, a continuous conformable sheet of Cretaceous sediments was laid down. Its greatest thickness was against the western shore of the ocean, namely, against the eastern base of the Wahsatch, where conformably over the top of the Jurassic shales are about 12,000 feet of Cretaceous beds. Passing eastward, this series in the province of the Great Plains near the eastern base of the Rocky Mountain system has thinned to 4,500 or 5,000 feet, and in western Kansas it reaches its thinnest development as described by the Geological Survey of that State. * * *

Throughout the whole Cretaceous, below the top of the Fox Hill, the molluscan fossils are invariably marine, with the exception of certain intercalated groups of purely fresh-water shells near the region of the Wahsatch, which, from their position close to the Cretaceous ocean shore, are evidently the in-washings of a fluviatile fauna.

Regarded as a whole, the basal member is a single sheet of siliceous sediments and rounded conglomerates from 300 to 500 feet thick. Over this lies the great Colorado group, 2,000 feet thick in the west, 1,000 feet thick in the region of the Great Plains, made up chiefly of fine calcareous and argillaceous material, which toward the middle of the group is prominently formed of marles or limestones.

Above the horizon of the Colorado group, the Fox Hill and Laramie are essentially of sandstones, about 9,000 feet in thickness in the region of the Wahsatch, about 3,000 feet in the region of the Great Plains. At the very summit of the uppermost or Laramie group are found Dinosaurs. The fauna up to the base of the Laramie is strictly marine. The Laramie itself carries the remains of an estuarial or brackish-water life, associated with strictly Mesozoic Saurians. With the close of the Cretaceous the conformable series of marine and estuarial deposits east of the Wahsatch come to an end, and the last moments of deposition were immediately followed by one of the most important orographical movements of the whole Cordilleran history.

From the eastern base of the Rocky Mountains to the eastern base of the Wahsatch the whole region was thrown either into wide undulations or sharp folds. So great a range as the Uinta, with its distinct, broad, flat anticlinal, was made at this period. Relatively to the present basin of the Colorado, the whole chain of the Rocky Mountains was elevated so as to define a broad, shallow depression, which now includes the waters of Colorado River. Powerful and important as this orographical movement was, it failed to disturb the coast deposits of the Pacific in California; but from reasons already given it seems probable that the first definition of the Cascade Range was caused by its force. In the general geology of North America the most important result of this immediately post-Cretaceous orographical movement was the elevation of the whole interior of the continent and the complete extinction of the inter-American mediterranean ocean.

From the date of this movement no marine waters have ever invaded the middle Cordilleras, and the subsequent strata are all of lacustrine origin. The effect of this orographical movement was to leave that part of the Cordilleras which falls within our study with a free drainage to the sea, with the single exception of the basin of Colorado River, which, from its configuration, immediately became the receptacle of the vast fresh-water Ute Lake, within whose area accumulated the important Vermilion Creek group, the earliest of the fresh-water Eocene strata. Throughout the entire Eocene period the basin of Colorado River was the theatre of a series of four Eocene lakes, whose deposits—unconformable among themselves, as has already been described—amount in all to 10,000 feet; lacustrine rocks characterized from the bottom to the top by an abundant series of vertebrate life covering the whole lapse of Eocene time. The Eocene of the Fortieth Parallel region was a period of four lakes superposed, the unconformity of their deposits due to four orographical disturbances.

An important orographical movement took place at the close of the Eocene, by which the province of the northern Great Plains and a long, narrow tract of Washington Territory, Oregon, Nevada, and California, lying on the eastern base of the Sierra Nevada and the present Cascade Range, became depressed and received

the drainage of the surrounding countries, forming two extended Miocene lakes. The deposits of the westernmost lake are chiefly the tuffs and rearranged ejecta of volcanic eruption. The deposits of the Plains are the simple detritus from the surrounding lands. The series on the west are over 4,000 feet thick; in the east they are not proved to be over 300 or 400 feet. Both contain abundant and typical Miocene vertebrate life.

The close of the Miocene was signalized by a powerful orographical movement over the area of the western Miocene lake, which threw the beds accumulated on its bottom into folds. Contemporaneously with this movement the Miocene lake of the east, by the subsidence of the surrounding country, increased so as to cover the province of the Great Plains.

The Pliocene opened, therefore, with two enormous lakes, one covering the basin country of Utah, Nevada, Idaho, and eastern Oregon; the other occupying the province of the Plains. The Pliocene deposits of the Plains lake are calcareous and sandy beds, which have no nonconformity in angle of dip with the underlying sheet of Miocene sediment, but which overlap it in every direction. The deposits of the great western lake are nonconformable with the Miocene and immensely overlap it to the east, doubling the area of Miocene sediment. Both of these Pliocene lakes — as do the Miocene — contain the remains of rich faunæ. The eastern lake received a maximum of about 2,000 feet of strata; the western lake has nowhere shown over 1,400 feet.

The close of the Pliocene was signalized by another orographical movement, which threw the sediments of the Great Plains lake into their inclined attitude, dipping 4,000 feet to the east and 7,000 feet to the south from the Fortieth Parallel region. This same orographical movement acted differently upon the sheet of sediments which covered the Pliocene lake of the Great Basin. Instead of tilting the entire lake, it broke in the middle, and the two sides were depressed from 1,000 to 2,000 feet thick, the shores faulting downward. The result of the post-Pliocene movement in the department of the Plains was to give thereafter a free drainage to the sea. The result in the area of the Great Basin was to leave two deep depressions, one at the western base of the Wahsatch, one at the base of the Sierra Nevada, which, in Quaternary times, received the abundant waters of the Glacial period and formed the two lakes that have already been described in the Quaternary chapter.

3. *An Elementary Geology, designed especially for the Interior States;* by E. B. Andrews, LL.D., of the Ohio Geological Corps, and late Professor in Marietta College. 283 pp. 8vo. Cincinnati, 1878. (Van Antwerp, Bragg & Co.)—In this little work on Elementary Geology, the author, as his preface remarks, has had especial reference to the Interior portion of the United States, exclusive of the Southern States. Many of the illustrations and facts are accordingly from the formations of the Mississippi Valley. It is still a general review of the science, presenting briefly facts

connected with Lithology and Dynamical Geology, and more fully Historical Geology. It is a popular work on the subject for the general reader and will be found a useful book for the young student. The volume is neatly printed.

4. *An Outline of General Geology, with copious References*, designed for the use of both General and Special students; by THEO. B. COMSTOCK, B.Ag., B.S., in charge of the Department of Geology, Paleontology and Economic Geology in Cornell University. 82 pp. 8vo. Ithaca, N. Y. Printed for the author at the University Press. 1878.—This work is based by the author on the Syllabus of his lectures to the students of Cornell University. It is a brief synopsis of the various branches of general geology, presenting in a condensed way the principles and conclusions with many prominent facts. It is well fitted for use in connection with a course of lectures; and the geological student will also find it valuable as a means of reviewing the subject. The work contains a list of references to various geological publications, including treatises, periodicals, transactions of Societies and memoirs, to aid the student in extending his range of study.

5. *Die Glimmergruppe.* II Theil, von G. TSCHERMAK.—The first part of Professor Tschermak's memoir on the Mica family has already been noticed in this Journal (xv, 150, Feburary, 1878), in that the results of his crystallographical and optical studies were given. To these he has now added a discussion of the chemical composition of the species as previously defined by him. His conclusions are based upon sixteen new analyses made with especial care to avoid the errors contained in many earlier analyses and in consequence of which most of them are rejected by him in his discussions. The following are the principal results adopted by him: (1.) BIOTITES: *Anomite*, composed of $Si_6Al_6K_4H_2O_{24}$ and $Si_6Mg_{12}O_{24}$ in ratios from 1 : 1 to 2 : 1; *Meroxene*, composed of $Si_6Al_6K_3H_3O_{24}$ and $Si_6Mg_{12}O_{24}$ in similar ratios. *Lepidomelane:* composition, $Si_6Al_6K_2H_4O_{24}(Si_6Fe_6K_2H_4O_{24})$ and $Si_6Mg_{12}O_{24}$ (2.) PHLOGOPITES: *Phlogopite*, composition, $Si_6Al_6K_6O_{24}$, also $Si_{10}H_8O_{24}$ (with $Si_{10}O_8F_{24}$) and $Si_6Mg_{12}O_{24}$ often in the ratio 3 : 1 : 4; *Zinnwaldite* (Cryophyllite), composition $Si_6Al_6K_6O_{24}$ $(Si_6Al_6Li_6O_{24}$ $Si_6Fe_{12}O_{24}$ and $Si_{10}F_{24}O_8$ in the ratio 10 : 2 : 3. MUSCOVITES: *Lepidolite*, composition $3Si_6Al_6K_6O_{24}(Si_6Al_6Li_6O_{24})$ and $Si_{10}O_8F_{24}$. *Muscovite* (Damourite), composition $Si_6Al_6K_2H_4O_{24}$ true muscovite, and also this same together with $Si_{10}H_8O_{24}$, in the ratio 3 : 1 (Phengite); *Paragonite*, composition $Si_6Al_6Na_2H_4O_{24}$. *Margarite*, $Si_4Al_8Ca_2H_4O_{24}$.—*Vienna Academy*, lxxviii, June, 1878.

III. BOTANY.

1. *On Plant-Distribution as a field for Geographical Research;* by W. T. THISELTON-DYER, Assistant Director of the Royal Gardens, Kew, London. 1878, pp. 36, 8vo.—This is a lecture, delivered (we believe) at the Royal Institution, and published originally in the Proceedings of the Royal Geographical Society, Lon-

don. Its teaching is interesting and truly noteworthy. It tells how "Vegetation in any given spot maintains its own only by having solved the problem of existing in the best way under the given circumstances. Introduce a new competitor for a particular site that can solve the problem rather more closely, and the old occupant must needs give way." It intimates that this must have been so all along geological time, and under all changes of climate, land and sea. It pictures the great hosts of plants oscillating between the poles and the equator, their ranks thinning by "the friction attendant on their movement," which has extinguished perhaps whole battalions. It takes a general survey of the prominent characteristics of the great floras, northern, southern and tropical, and of their principal divisions. It brings prominently forward "the opinion that the northern hemisphere has always played the most important part in the evolution and distribution of new vegetable types; in other words, that a greater number of plants have migrated from the north to the south [meaning across the tropics] than in a reverse direction." That proposition (based on the temperate floras) is well sustained by obvious facts, and follows almost of course from the greater amount and longitudinal contiguity of northern lands, as Mr. Darwin has "suspected." But this may probably be limited to the extant vegetation and its nearer predecessors. If the paleontological botanists are at all correct in their ordinal determinations, the reverse might well have been the case at earlier periods, when Proteaceæ and Laurineæ abounded in northern temperate regions. It must needs have been so if there was for any long period a preponderance of southern land with northward extension.

A good part of the lecture—as rich in practical value as the remainder is in theoretical interest—recounts what geographical explorers have recently been doing for botany by collecting materials and information, indicates how very much is yet to be done in this way, how easy it is to collect and preserve botanical specimens, and what important services the "roving Englishman" and still more the desciplined explorer, may render to the botanical studies. A. G.

2. *Conspectus Floræ Europææ*, auctore C. F. NYMAN. Orelso Suecias, 1878. I. *Ranunculaceæ—Pomaceæ.* pp. 240, 8vo.—This systematic catalogue of European plants, arranged in the Candollean order, with leading references, principal synonyms, and localities, supplies a desideratum, so far as it extends, and the second part, which will include the remaining *Polypetalæ*, is announced as in press. It is evidently a work of critical importance, and is well arranged. A. G.

3. *Botanical Necrology of* 1878.—An unusual number of botanists have deceased in the course of the past year. The first and the last names on the list are venerable.

ELIAS MAGNUS FRIES, of Upsal, died February 8, 1878, in the eighty-fourth year of his age, a month after the hundredth anniversary of the death of Linnæus at that ancient University. He

was born, as was Linnæus, in the south of Sweden, was educated at Lund, where he was early made demonstrator of Botany, and was translated to Upsal more than forty years ago, where he occupied the chair, not of Botany, but of Practical Economy, answering, we suppose, to Rural Economy. He was, nevertheless, the greatest Swedish botanist since Linnæus, and the last survivor of those whose teachers were taught by Linnæus. He began to publish on Phænogamous Botany in the year 1814, in which department he was high authority to the last; but soon took up Lichens and Fungi, in the latter of which his knowledge was unrivalled and his judgment wonderfully correct, considering that his studies were unaided by the compound microscope. His last work of any consequence was a new edition of his *Hymenomycetes Europæi*, of which he wrote the preface on his 81st birthday, August 15, 1874.

LUDWIG PFEIFFER, of Cassel, died at the beginning of the year, at the age of 72. He wrote on *Cacteæ*, and published a Synonymia Botanica.

ANDREW MURRAY, a writer to the signet at Edinburgh, where he was born, died January 10, 1878, at the age of 66. He was an entomologist more than a botanist; but he came up to London to become the acting Secretary of the Horticultural Society, and became learned in *Coniferæ*, publishing a volume on the Pines and Firs of Japan in 1863, and, later, various articles upon the *Coniferæ* of our Pacific Coast.

ANDREW BLOXAM, an English clergyman, one of the earliest of the critical investigators of *Rubus*,—a genus which perplexes European botanists,—died February 2, 1877, at the age of 76.

FRANÇOIS VINCENT RASPAIL, whose name has for many years past been associated with radical politics, was in earlier years a keen but eccentric botanist. His memoir on the Grasses, with a new classification, was published at Paris in the year 1825; his new system of Vegetable Physiology and Botany in 1837. He died at Arcueil, near Paris, January 6, 1877, at the age of 87.

SULPIZ KURZ, Curator of the Calcutta Herbarium, and an active botanist, died at Palo-Penang, January 15, 1878. Age and birth unknown to us; but he was a pupil of von Martius at Munich, and went early to Java, whence he was transferred to British India, and was a valuable explorer. His Forest Flora of British Burma, in two volumes, was published at Calcutta last year, about the time of the author's death.

M. DURIEU (de Maisonneuve), long the director of the Botanic Garden at Bordeaux, author of many botanical and vinicultural papers, and of the first (Cryptogamic) part of a Flora of Algeria, died at Bordeaux, Feb. 20, 1878, at the age of 82.

CHARLES PICKERING, M.D., who died in Boston on the 17th of March last, in the 73d year of his age, and to whose memory a tribute has already been paid in this Journal, must be counted among the botanists, although most of his life was devoted to zoology, anthropology, and cognate studies. His extensive

work On the Geographical Distribution of Plants and Animals is a collection of materials for the study of the subject; and a bulky volume entitled Man's Record of his own Existence—the printing of which was in progress when the author died, and which is not yet published—is largely a record of changes in the habitat of plants effected under human agency, from B. C. 4491 down to recent times. It is a monument of wonderful industry.

MORITZ SEUBERT, Professor of Botany at Carlsruhe, author of a Flora of the Azores on Hochstetter's collections and notes, and of a monograph of *Elatineæ*, also of several monographs in the Flora Brasiliensis, died April 6, in the 60th year of his age.

THOMAS THOMSON, M.D., the well-known associate of Sir Joseph Hooker in Himalayan exploration, and in the Indian Flora, the explorer of Thibet, sometime Director of the Calcutta Botanic Garden,—a botanist whose career of high promise, was sadly cut short by ill health—died in London on the 18th of April last, at the age of 60. He was the son of the distinguished chemist Thomas Thomson, of Glasgow, where the lamented subject of this notice was born and educated.

GIOVANNI ZANARDINI, Professor of Botany at Venice, patriarch of Italian Phycologists, died, April 24, at the age of 74.

ROBERTO DE VISIANI, Professor of Botany in Padua for many years, author of a Flora Dalmatica, and of many interesting papers, died on the 4th of May, at the age of 77.

BARTHELEMY CHARLES DUMORTIER, of Tournai, Belgium—long eminent as a statesman as well as botanist (the leader of the clerical party in Belgium politics), and greatly esteemed as a man—died July 9, in his 82d year. His earliest papers bear the date of 1822; he published on *Hepaticæ* in 1831, and again in 1871. He published on Grasses in 1823 and again in 1868. He brought out a new and elaborate classification of fruits in 1835.

ELIAS BORSZCZOW (whose name we could not presume to pronounce), Professor of Botany and Director of the Botanic Garden of Kiew, in Southern Russia,—who in 1858 botanically explored the Aral-Caspian desert, and published a monograph of the plants yielding galbanum and assa-fœtida,—died on the 12th of May.

JAMES MCNAB, Curator of the Edinburgh Botanical Gardens, as was his father before him, sometime President of the Edinburgh Botanical Society, the most accomplished of cultivators, and a well-informed botanist, died on the 20th of November, in his 69th year. We well remember his visit to the United States in the year 1834.

STEPHEN T. OLNEY, of Providence, Rhode Island, died July 27, 1878, at the age of 66. He was for many years one of the most active local botanists of this country; published in 1845 a Catalogue of Rhode Island Plants, with continuations and emendations in 1846 and 1847; a List of Rhode Island Algæ in 1871; in the latter years of botanical activity studied Carices with critical care and minuteness, published several fascicles of Exsiccatæ, admirably prepared; and formed a fine and rich herbarium and

library, which he gave to Brown University. To it also, or at least to his native State, he made handsome legacies for botanical instruction, as well as other benevolent bequests. These benefactions, and his many good offices, should preserve a pleasant memory of a useful life, the end of which was obscured and afflicted by mental trouble. In Botany his name is commemorated by a remarkable Leguminous tree of Arizona (*Olneya*) and by several species of his own discovery. Mr. Olney was unmarried, and was for most of his life engaged in business, at first in Augusta, Georgia, and afterward in his native town.

James Watson Robbins, M.D., died at Uxbridge, Massachusetts (where he resided and was an esteemed physician for the greater part of a long life), on the 9th day of January, 1879, at the age of 77. With the exception of Dr. Bigelow he was the oldest New England botanist, and perhaps the oldest in the United States; and, within his range, he was certainly one of the most careful and accurate. He was a colleague of William Oakes, who had the pleasure of naming several species discovered by him in his honor, and he had an extended correspondence with all our botanists. He collected not only throughout New England, but in Virginia and Maryland, where he resided for several years when a young man, and on the shore of Lake Superior, where he spent four years. Of late, he devoted his attention mainly to aquatic phænogamous plants, especially to the difficult genus *Potamogeton.* He contributed the monograph of this genus to the last edition of Gray's Manual. He first detected that simplest and smallest of flowering plants, *Wolffia*, in this country. His excellence and amiability secured the attachment of all who knew him. He was born at Colebrook, Conn., November 18, 1801, graduated at Yale College in 1822, and there took his medical degree in 1828. In his death we have lost the most critical student of the botany of New England and the Northern Atlantic States.

Jacob Bigelow, the most venerable of botanists, even more distinguished as a physician, a cultivator of the fine and useful arts, and a scholar, one of the most rounded and symmetrically developed men of his time and place, died at Boston, on the 10th of January ult. The notice due to his life and services must be deferred to the next number. A. G.

IV. Miscellaneous Scientific Intelligence.

1. *Technologisches Wörterbuch ;* I. Deutsch-Englisch-Französisch; bearbeitet von E. Althans, L. Bach, u. A., herausgegeben von Carl von Albert, mit einem Vorwort von Dr. Karl Karmarsch. Dritte verbesserte und bedeutend vermehrte Auflage. 743 pp. 8vo. Wiesbaden, 1877. (J. F. Bergmann; B. Westermann & Co. in New York.)—This Technological Dictionary deserves high commendation both for its completeness and its accuracy. The subjects which it embraces include all the prominent branches as well of pure as of applied science, so that the work is alike valu-

able to the student and the manufacturer, the technologist and the merchant. This volume gives the English and French equivalents of the German technical and scientific words and expressions; the other two volumes of the series are arranged for English and French readers respectively. The names of seventeen specialists are given, who have assisted in the preparation of this the third edition of the first volume, and they alone are a sufficient proof of the excellence of the work.

2. *Chromometry.*—Under this name Professor Kœnig describes a new branch of quantitative analysis with the blowpipe. The method depends upon the observations of the color produced in the borax bead by various metallic oxides, with the "Chromometer"; in the hands of the describer it is made to yield very accurate results.—*Amer. Soc. Philadelphia*, Oct. 4, 1878.

3. *Additional characters of the Sauropoda;* by O. C. Marsh.—Beside the characters of the *Sauropoda*, already made known by the writer,* others of importance have been since brought to light.

The skull, of which so little has been known hitherto in the Dinosaurs, presents in *Morosaurus grandis* some strongly lacertian characters. It is short, high and narrow, something like that of the Chameleon. The supra-occipital is very large, and forms the upper part of the foramen magnum. The ex-occipitals have long par-occipital processes. The occipital condyle is formed entirely of the basi-occipital. The long basipterygoid processes are of the lacertian type. The quadrate is elongated, very slender above, and has a small articular head. Below, it is fixed by the pterygoid, which unites with it by suture. On the outer side of the quadrate, below the middle, the quadrato-jugal joins it by suture. Its posterior end is cup-shaped, with the cavity opening outward, and partially closed by a thumb-like process. This bone divides in front, one branch going upward, and the other forward, to join the jugal and complete the lower arch. The bones of the cranium were united by open sutures, and there are large parietal fossæ. The orbits are large, and there is a vacuity in front of the lachrymal. The upper jaws are especially short and deep, and each maxillary contained nine teeth. The nasals and premaxillaries were narrow. The lower jaws were not coössified at the symphysis, and each dentary bore twelve teeth. This bone was very deep in front, and pointed behind.

Episternal bone.—A bone, found with the remains of *Apatosaurus ajax*, so strongly resembles the episternal element in lizards, that it must be regarded as an episternal bone. It is cruciform in shape, and symmetrically bilateral. The posterior process is abruptly truncated; the anterior is short and obtuse, and the lateral processes are the longest. The lower surface of this bone is slightly convex on the median line, and more strongly convex transversely. The upper surface and sides indicate that it was surrounded mainly by cartilage. By this interpretation of the bone, the posterior truncated process abutted against the sternum,

* This Journal, vol. xvi, p. 411, and vol. xvii. p. 85.

the posterior reëntrant angles were met by the coracoids, or the intervening cartilage. This would leave the anterior concavities for clavicles, no evidence of which has hitherto been found in Dinosaurs. Their existence in *Apatosaurus*, if not in other *Sauropoda*, seems therefore a necessity. The large rugose facet on the anterior projection of the scapula offers the natural place for union with that bone. No clavicles were found with this episternal bone, but a single specimen from a neighboring locality agrees closely with what we should expect the corresponding clavicle to be. These interesting remains will be more fully described by the writer in another communication.

Yale College, January 22, 1879.

4. *Portrait of Humboldt.*—An excellent portrait, of natural size, painted by Steuben, belongs to Madame de Schœnfeld, of Paris, and is to be disposed of. It should be in some of the Galleries or Museums of this country. Information respecting it may be sought of the distinguished botanist, E. Cosson, 7 Rue Abbatucci, Paris.

THE

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[THIRD SERIES.]

ART. XXI.—*On the Variability of the Ultimate Molecule;* by Professor W. A. NORTON.

I PROPOSE, in the present article, to adduce numerous facts which seem to afford decisive evidence that the ultimate molecules of bodies, under varying conditions of pressure and other relations to surrounding molecules, are subject to change in the intensities of the forces of attraction or repulsion they are capable of exerting, at a given distance, on such contiguous molecules; while retaining the same temperature and the same chemical constitution.

The first evidence I shall present that the ultimate molecule may, under certain conditions, experience a change in the intensities of its active forces, is derived from the *facts and phenomena of the set, or permanent distortion of materials*, which remains after they have been temporarily subjected to a force of stress.

Numerous series of experiments have been made by Fairbairn, Hodgkinson, Chevandier and Wertheim, Morin, and other experimenters, the writer included, with the view of determining the amount of set experienced by various materials, after a certain fraction of the breaking load has been applied and withdrawn; and of ascertaining all the laws of the set, under varying loads, variations in the duration of stress, varying conditions in the application of repeated stresses, etc. The following are some of the principal facts and laws that have been experimentally determined.

(1.) If a bar of any material (e. g. wood, iron, or steel) be subjected to varying forces of stress—whether tensile, compres-

sive, or transverse—increasing progressively from a small fraction of the breaking load, on the removal of the load a certain set will remain, which will increase steadily with the amount of the load. The progressively increasing set will be proportional to a power of the load which varies, more or less, from one material to another, and for the same material with the ratio of the load to the breaking weight. The law of variation falls, in general, between the first and fourth power of the load; but when the stress is a large fraction of the breaking load, the set may increase according to a much more rapid law. This is strikingly true of wrought iron.

(2.) There is, strictly speaking, no definite limit of elasticity, that is, no minimum limit of the load below which no set results. This fact was decisively made out by Hodgkinson in his experiments on the behavior of wrought iron under a tensile stress, by Chevandier and Wertheim in their extensive course of experiments on numerous varieties of wood, variously strained, and in the writer's experiments on the set, or residual deflection, of bars of wood, iron and steel, after a transverse stress. In the last mentioned series of experimental determinations, a perceptible set was obtained, with each material, immediately after the stress was removed, however small its amount, until it fell below the lowest possible determination of which the apparatus was capable (viz: $\frac{1}{10000}$ of an inch); and on increasing the delicacy of the measuring apparatus it was found that the least perceptible immediate set was still limited only by the capability of detecting, with the apparatus, minute displacements.

We may say, then, that every load, however small, gives rise to an immediate set;* and that the set increases progressively with the load, however small the increments of load may be, up to the point of rupture. If for any ordinary material, there is a limiting load below which no immediate set results, such limit has not yet been determined.

(3.) The set augments with the duration of the stress, up to a certain interval of time. When moderate strains are applied it has been found that this limiting interval may vary, with the strain, from a few minutes to one hour. In experiments with white pine subjected to a transverse stress, a set from five to nine times greater was obtained by prolonging the stress.

(4.) The amount of the set does not remain invariably the same for an indefinite time after the stress is withdrawn, but is subject to material fluctuations. If very small it may pass off entirely in a few minutes. Otherwise, after decreasing for a short interval of time (from 5m. to 20m., in the author's

* By immediate set is meant that which obtains immediately after the stress is withdrawn.

experiments) it increases for a longer interval. This increase of set is eventually succeeded by another decrease; which may again be followed by other smaller fluctuations extending over several hours. As a final result the set subsides entirely, or settles into a permanent value; according to the amount and duration of the stress applied.

These facts lead unmistakably to the conclusion that the molecules of the materials experimented on, as a result of the temporary application of the force of stress, experienced an abiding change of dimensions or mechanical condition, by reason of which the intensities of their mutual actions no longer remained the same at the same distance, as before the stress was temporarily applied, and hence did not return precisely to their former configuration or relative positions; also that this molecular change increased progressively with the amount of the stress, and, to a certain extent, with the prolongation of the stress; and that the disturbed molecules, in acquiring their new mechanical condition, fluctuated more or less to the one side and the other of the final state of equilibrium. To make this more evident, let us consider somewhat in detail the results of a single series of experiments; for example, those made by Captain Rodman (U. S. Army) on a cylinder of cast iron, 35 inches long and 1·366 inches in diameter, subjected to a tensile stress. The smallest set observed was $\frac{1}{714000}$ of the length, and resulted from the temporary application of a tensile stress of 6,000 pounds to the square inch. This stress, temporarily applied, had then the effect to produce an abiding increase of $\frac{1}{714000}$ in the distance between two contiguous molecules in the line of stress. Loads increasing by 1,000 pounds, from 6,000 pounds to 25,000 pounds per square inch, were successively applied at considerable intervals of time, and the resulting sets, or permanent elongations, increased progressively from $\frac{1}{714000}$ to $\frac{1}{5000}$ of the length; and accordingly the distance between contiguous molecules in the line of stress were augmented by the same fractional amounts. The direct operation of these loads, before being withdrawn, augmented the molecular distances by fractional amounts varying from $\frac{1}{3700}$ to $\frac{1}{385}$. Now this bar of cast iron was a mass of molecules which, whenever no external stress was in actual operation, must have been in equilibrium under the operation of antagonistic forces of attraction and repulsion exerted by the molecules, and yet as the result of a temporary application of a series of increasing loads, twenty in number, it took up a series of as many different configurations, in which the distance between contiguous molecules in the line of stress augmented progressively from $\frac{1}{714000}$ to $\frac{1}{5000}$; and this although the actual displacements produced by the suspended loads were only from

$\frac{1}{3700}$ to $\frac{1}{385}$. To suppose that these molecules, during all these progressive permanent changes of mutual distance, continued to exert forces of mutual action varying only with the distance, is to suppose that they were capable of taking, under the operation of such forces, constant at the same distance, an indefinite series of positions of equilibrium differing from each other by exceedingly minute fractions of the distances between the molecules. The absurdity of this supposition is still more apparent when we consider that we must also admit that the molecules were capable of being in equilibrium, in relative positions which it required at the outset certain forces of stress to bring them into, although the inherent molecular forces are not supposed to have changed. Without violating fundamental principles of Statics, we cannot escape from the conclusion that the molecules must have undergone some change, under the operation of the temporary strains developed within the bar by the external stress, by reason of which they exerted mutual actions that had no longer the same intensity, at the same distance, as before the stress was applied. To suppose that the bar was not homogeneous throughout, would here be of no avail, for whatever its inequalities of constitution or texture, at all points of its mass the equilibrium must obtain under the operation of the inherent forces of the molecules there present, whether like or unlike. Besides the fact of a progressive increase of set, by minute degrees, while the stress augments by small fractions of the breaking load, is found to hold good whether the body is in the condition of cast iron, or wrought iron, or wood (a material that has resulted from a natural growth). This statement also disposes of the conjectural explanation of the phenomena of set which has sometimes been given, that they are attributable to a relief of the particles of the body from internal strains subsisting before the stress is applied. For, if it were possible to form any distinct conception of such internal strains that could give rise to such phenomena, it is idle to suppose that all varieties of material, and all the diverse specimens of the same material, are habitually in similar states of internal strain. On the other hand, if we admit that the molecules may be susceptible of variation in their mechanical condition, under the influence of their mutual, effective attractions, or repulsions, when forced out of their relative positions of equilibrium, and that a fraction of this molecular change may abide after the external stress is withdrawn, we have a simple, general explanation of the phenomena of set, and a satisfactory basis for a definite theory of imperfect elasticity. A body which is imperfectly elastic under a certain external force of stress, would be simply one whose molecules experience a sensible permanent change of mechanical condi-

tion as the result of the operation of this force of stress. When the load is removed the body should then have a certain set.

We may add here, incidentally, that all facts and phenomena in which imperfect elasticity plays any part (e. g. the properties of ductility, malleability and plasticity), are so many additional evidences of variations occurring in the mechanical state of the molecule.

A second general evidence that the ultimate molecule is liable to variation, may be derived from the observed changes in the mechanical properties of materials produced by tension, pressure, heat, etc. Thus the enacity of iron may be greatly increased by wire-drawing, also by hammering and rolling when heated. This is generally explained by saying that the particles have been brought into new relative positions; though the effect in the latter case is attributed in part to the removal of impurities. Such an explanation is little better than a statement of the fact that a change of configuration has occurred, and the tenacity has in consequence increased. It neither states what the change of configuration is, nor why it is possible while the inherent forces of the molecules are supposed to remain the same, nor why it should be attended with an increase of tenacity.

The tenacity of bar iron may also be materially increased by the process of thermo-tension. This consists in subjecting the bar to a large tensile stress, while heated to about 400° F., and then allowing it to cool after being relieved of strain. The tenacity of good bar iron may be increased from 12 to 20 per cent by this process. At the same time the bar has become permanently elongated by about 6 per cent. The precise amount of the effect varies with the temperature to which the bar is raised, and the intensity of the tensile stress applied. Shall we assume, then, that the molecules, while retaining the same forces, have taken up an indefinite series of positions of equilibrium, varying progressively with the number of degrees of temperature and the number of pounds of stress, or admit at once that under the varying conditions of temperature and stress, permanent variations in the intensities of their active forces must have taken place, and thus new configurations have become possible, attended with augmentations of tenacity. In all such cases it must be borne in mind that the displacements of the molecules are but small fractions of the distances between them.

We will add that the well-known effects of tempering and annealing, also give intimations of permanent changes effected by variations of temperature in the mechanical condition of the individual molecules.

Let it not be understood that in what precedes, the intention

has been to convey the idea that the molecular displacements produced by wire-drawing and hammering, and the permanent changes of mechanical properties that may result from the operation for a time of a force of tension, or pressure, or a change of temperature, must be, in every instance, wholly ascribed to variations of molecular condition; but that such variations must play an important part in the mechanical processes of change, and constitute one mechanical feature of the substances thus specially affected.

Another evidence that the ultimate molecule has the property of variability, is furnished by the great change of mechanical properties that sometimes results from the presence in a body of minute quantities of other substances (e. g., the great changes in the tenacity and other properties of steel, attendant on slight variations in the percentage of carbon associated with the iron; and in the tenacity of iron or steel resulting from slight differences in the percentage of manganese, phosphorus, etc.) According to the results of the experiments of Kirkaldy on Fagersta steel (Sweden), the union of 0·5 per cent (or $\frac{1}{200}$) of carbon with the iron augmented the tenacity of the hammered bars from $\frac{1}{8}$ to $\frac{1}{5}$, and an increase in the quantity of carbon from 0·5 per cent to 1 per cent (from $\frac{1}{200}$ to $\frac{1}{100}$) augmented the tenacity from $\frac{1}{5}$ to $\frac{1}{3}$. The presence of $\frac{1}{200}$ by weight of carbon, would give only one chemical molecule of carbon for every forty-three chemical molecules of iron; and of $\frac{1}{100}$, only one molecule of carbon to every twenty-one molecules of iron. The following table, extracted from the Article on Steel, in Johnson's Cyclopedia, by Mr. A. L. Holley, gives the comparative effects on the mechanical qualities of steel of several different proportions of carbon.

Fagersta (Sweden).			Neuburg (Austria).		
Quantity of Carbon.	Av. Breaking Load.	Per centage of Stretching.	Quantity of Carbon.	Av. Breaking Load.	Per centage of Stretching.
	lbs. per sq. in.			lbs. per sq. in.	
1·00 p. c.	126, 486 to 146, 383	2 to 6 p. c.	0·88 to 1·12	126, 486 to 149, 226	5 p. c.
0·70 p. c.	100, 905 to 130, 750	4 to 6 p. c.	0·62 to 0·88	103, 747 to 126, 486	5 to 10 p. c.
0·45 p. c.	99, 404 to 103, 747	9 to 10 p. c.	0·38 to 0·62	80, 298 to 103,747	10 to 20 p. c.
0·35 p. c.	68, 217 to 69, 638	12 p. c.	0·15 to 0·38	68, 217 to 80, 298	20 to 25 p. c.
0·30 p. c.	59, 690 to 62, 533	11 to 22 p. c.	0·05 to 0·15	56, 848 to 68, 217	25 to 30 p. c.

It will be seen that with the Fagersta steel an increase in the proportion of carbon from 0·30 of 1 per cent to 1 per cent (or $\frac{1}{143}$) more than doubled the tenacity; and that with the Neu-

burg steel an increase in the proportion of carbon from 0·15 per cent to 1·12 per cent (or about $\frac{1}{100}$) augmented the tenacity in the ratio of $2\frac{1}{2}$ to 1.

It has been shown by recent experiments* that an increase in the percentage of manganese in Bessemer steel from 0·5 per cent to 1 per cent, while the percentage of carbon and phosphorus remain the same, may augment the tenacity of the steel, when untempered, by one-fifth, and when tempered in oil by one-quarter. In this case but one molecule of manganese is added to every two hundred molecules of iron.

The magnitude of these variations of tenacity is greatly disproportionate to the quantity of carbon, or manganese, associated with the iron. Nor can such mechanical effects, increasing progressively with the percentage of the ingredient, be reasonably attributed to continued variations in the number of atoms in the physical molecules, or in the configurations of unvarying molecules. It would seem that their possibility, on physical grounds, can only be conceived by admitting that the iron molecules, which combine with the carbon molecules, suffer in consequence some physical change by reason of which the intensities of their attractive actions on surrounding molecules are increased, and that these molecular changes extend, by propagation from one molecule to another, throughout the entire mass.

Additional intimations that the ultimate molecule has the property of variability, are furnished by certain facts in *Chemical Physics.*

(1.) In solution, solids assume the mechanical properties of liquids. The entire mass of the solution is in the liquid state, and, to all appearance, the molecules of the dissolved solid are as truly in the liquid condition as those of the solvent. The molecules of the solid have not suffered any change of chemical composition. The natural inference then is, that they have experienced a change of mechanical condition. The alternative supposition is that the physical molecules of the solid are more complex than the chemical molecules, and in the process of solution are broken up into others less complex, which, in their association, have the mechanical properties of a liquid.

(2.) Certain elementary substances have the property of *Allotropy*, that is of assuming, under varying circumstances, different states or forms in which they exhibit very different physical and chemical properties. Sulphur, phosphorus, oxygen, and carbon, may be cited as conspicuous examples. "Several other elements are known to be capable of existing in

* On the Effects of Phosphorus and Manganese on the Mechanical Properties of Steel; by M. Euverte (Van Nostrand's Engineering Magazine, April, 1878, p. 363, etc.).

two or more allotropic states. Indeed, instances of allotropy are so common that some chemists have been led to believe that most, if not all, of the elements may exist in distinct allotropic states." In some cases (e. g., sulphur, phosphorus and carbon) the substances occur in different states of solidification—crystalline, vitreous, or amorphous—that is, their molecules occupy different relative positions of equilibrium. Now the capability of taking up these different positions is an intimation of a probable difference in the mechanical condition of the ultimate molecules. "Diversity of crystalline structure, or its entire absence, is, however, evidently only one of the many differences of properties incidental to allotropism; in many cases it must be regarded as a consequence of the latter, by no means its cause. At all events the cases of allotropism which occur among the gases, cannot be explained by this theory" (i. e., by a mere difference of molecular arrangement.) The diverse chemical properties generally exhibited in the different allotropic states of a substance must apparently be attributable to diversities in the condition of the individual molecules; and so be regarded as evidence in support of the doctrine of the variability of molecules. In fact Berzelius suggested the term allotropism as expressive of the idea that the diversities of property observed might depend on some absolute difference of quality in the different varieties of a substance, and not upon any dissimilarity in the arrangement or number of its molecules; and we are told "that this idea has ever since steadily gained favor, although directly opposed to the doctrine of the immutability of matter, one of the principal tenets on which the chemistry of the first half of the century was based."

While in allotropism we have the significant fact that the same element can exhibit the properties of two different substances, we have in *isomerism* a kindred fact,—that the same substances combined in precisely the same proportions may form two or more compounds differing widely from each other in their chemical and physical properties. Whatever may be the supposed differences of molecular arrangement in these varying compounds, such differences must apparently find their efficient cause in varied mechanical and physical states assumed by the individual molecules of the constituent substances. That varying circumstances of combination should suffice to determine all the supposed diversities of arrangement of molecules, while the combining "chemical atoms" retain the same intensity of mutual action, seems in the highest degree improbable. In many, if not all the cases of isomerism, there must apparently be a true allotropy, or change of state of the ultimate molecule of the different elements combined.

In corroboration of the evidence of the variability of mole-

cules furnished by allotropism and isomerism, we may mention that "many well known substances exhibit differences in hardness, color, specific gravity, solubility, etc., according to the circumstances in which they are produced."

(3.) Some substances in the *nascent state* exhibit chemical properties, which they do not possess, or, if at all, only in an inferior degree, in the ordinary free state. Thus oxygen, hydrogen, and nitrogen, are much more active, chemically, in the nascent than in the free state. We must then suppose that the chemical molecules either differ in these two states, in the number of their constituent atoms, or in the physical and mechanical condition on which their chemical activities depend, without any difference in the number of constituent atoms. The former supposition involves the improbable hypothesis that the same atoms regarded as endued with inherent forces of a constant intensity, may take up two or more different relative positions of equilibrium.

The citation of facts, mechanical, physical, and chemical, which furnish evidence that the ultimate molecule is liable to variation, might be extended almost indefinitely. In fact, in every change of state which a body may experience, and in almost every change of physical relation to other substances, the active forces exerted by the molecules on one another are different in intensity—though the temperature remain the same; and, in general, after the body has been subjected to any mechanical process, the molecules manifest different intensities of mutual action. Many physical processes are attended with similar results. Some of these variations of molecular condition have been conjecturally explained by the vague hypothesis that the particles are differently arranged—either that the existing molecules, regarded as groups of kindred atoms, take on different configurations, or become broken up and replaced by others. But others are of such a character that this explanation is wholly inadmissible (see p. 185); and, in general, no definite theory is offered of a mechanical process by which such supposed changes in the constitution of the molecules may be brought about.

If, in view of the array of evidence that has now been presented, it be admitted that the ultimate molecule has the property of variability, in the sense that has been defined, under varying mechanical relations to other molecules, and the molecule be regarded merely as a group of kindred atoms, then we must conclude that *these atoms are also variable*, after the same manner as the molecule itself. For it is obvious that a group of kindred atoms cannot exercise an external action varying in intensity at a given distance, and increasing progressively with the amount of change experienced in its mechanical relations

to surrounding molecules, if the inherent atomic forces suffer no change. But to suppose that the inherent atomic forces vary in intensity at a given distance, is to discard the ordinary conception of the atom, which is that it is not only invariable in its mass and volume, but also in the intensity of action, whether attractive or repulsive, it is capable of exerting on another atom at a given distance from it. We are accordingly constrained to regard the elementary parts of molecules, which have received the designation of atoms ("chemical atoms") as in reality liable to variation in their capabilities of mechanical action. But we are not therefore under the necessity of rejecting the fundamental idea of invariable atoms, for we may instead regard the "chemical atom" as consisting of a true atom of ordinary matter invested with an ethereal atmosphere, and thus as being an organized mechanical system, that may be capable of variation in its dimensions and force of external action at the unit of distance, with varying external relations—though the inherent forces of all the atoms in the system remain unchanged. This is the general conception of the "chemical atom" which I have adopted in my papers on Molecular Physics.* Upon this view the chemical atom, and the molecule (chemical or physical) have the same general constitution, and differ only in the precise mechanical state of the ethereal atmosphere that invests the atom proper. To this last element of bodies, incapable of change in its mass as measured by its weight, I have given the designation of the *ultimate molecule*. The mutual actions of ultimate molecules constitute the *molecular forces;* and so include, taken in the most comprehensive sense, the mutual actions of ultimate molecules in the different state answering to the "chemical atom," "chemical molecule," and "physical molecule." Upon this hypothesis, with regard to the constitution of the chemical atom and molecule, it is the investiture of the atom proper with an ethereal atmosphere that has armed it with the power of operating on adjacent atoms; and, at the same time, imparted to it its properties with respect to the physical agents of light, heat and electricity. The definite conception I have formed of the constitution of this ethereal atmosphere, is not that it is simply a mass of luminiferous ether condensed around the atom. Such an atmosphere, perfectly elastic, would be incapable of permanent change as a consequence of temporary variations of external pressure. Besides, while researches in Physical Optics have led to the conclusion that the atoms of bodies are probably surrounded by such atmospheres, electric phenomena give intimation of the presence in bodies, and in intimate association with their molecules, of a subtile fluid termed the "electric

* This Journal, July, 1864, and May, 1872.

fluid," or ether. It has been shown by physicists that certain of these phenomena do not absolutely require the admission of an ether distinct from the luminiferous, but the same cannot be said of electric phenomena in general. Moreover, all the efforts hitherto made to explain electric phenomena by hypothetical motions of the atoms of bodies, have proved futile. No definite physical theory of electricity has been framed that does not involve the conception of a subtile electric fluid, the atoms of which repel each other, and are attracted by those of ordinary bodies; and we have as yet no sufficient reason for abandoning the original hypothesis that this fluid is distinct from the luminiferous ether. If, then, there be an electric ether distinct from the luminiferous and presumably less subtile (i. e. made up of larger atoms) the ethereal atmosphere condensed around an atom by its attractive action, should consist of an atmosphere of luminiferous ether and an *envelope* of electric ether immersed within this for a certain depth. Such is the definite conception I have adopted of the constitution of the molecular atmosphere. It may be characterized as an ethereo-electric atmosphere. From this combined with the fundamental hypothesis that recurring impulses are incessantly exerted on one another, by all the atoms, ethereal and non-ethereal, that make up the ultimate molecule, I have deduced the operation of certain molecular forces. The two ethers condensed around the atoms, and pervading the interstices between them, are constituted as media capable of transmitting wave actions, by the permanent statical repulsion exerted between their atoms. The recurring impulses just mentioned originate such wave actions which are propagated from one molecule to another. The attractive impulses exerted by the central atom of a molecule on its electric envelope, originate in it waves that take effect attractively on contiguous molecules. On the other hand, the repulsive impulses exerted by the atoms of the envelope on each other, originate waves that take effect repulsively on these molecules. In considering the action of one molecule on another contiguous to it, the virtual center of the first system of waves will be somewhat without the inner surface of the envelope, and that of the other system somewhat within its outer surface—both centers being on the line of the centers of the two molecules. It is farther to be observed, that the subsidences of the envelope, induced by the attractive impulses from the central nucleus, should originate waves in the dense luminiferous ether, posited below the envelope, which would be propagated indefinitely outward and take effect on the contiguous molecule as repulsive pulses. But this system of wave-actions may be combined with the attractive system into resultant attractive actions. The different

sets of waves, emanating from different virtual centers, will be propagated according to the law of inverse squares. The *effective* action of one molecule on a contiguous one will be the difference between the resultant attractive action just mentioned, and the opposing action of the system of repulsive waves first mentioned. The following is the general expression for this *force of effective molecular action.**

$$f=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2}-\frac{m}{x^2}, \quad (1)$$

in which x denotes the distance between the molecular envelopes, r the distance between the center of the system of repulsive waves first mentioned and that of the system of attractive waves, n the coëfficient of attraction, and m that of repulsion. If we put $x=ur$, $\frac{n}{m}=k$, and $\frac{m}{r^2}=p$, this expression becomes

$$f=\left(\frac{k(3+2u)}{(1+u)^2(2+u)^2}-\frac{1}{u^2}\right)p. \quad (2)$$

The first term represents the attractive action, the other the repulsive. I propose, in a subsequent paper, to apply to this physical formula numerous quantitative and qualitative tests.†

From the point of view taken in the present discussion the important question here arises, whether the ultimate molecule as it has been defined, endued with the forces of external action just specified, is susceptible of permanent variation, and if so, how? It is, in fact, not difficult to see that it may be subject to variation in its dimensions, and in the coëfficients (n and m) of its attractive and repulsive wave impulses, under variations of pressure. Suppose that the external pressure is increased, and the ultimate molecules are thus urged nearer to each other, the molecular envelopes will in consequence be compressed, and the dimensions of the molecules, as well as their coëfficients of attraction and repulsion be altered. When the compressing force is withdrawn, if the dense luminiferous ether posited between the envelopes and the central atoms of the ultimate molecules has been merely compressed without any diminution of its quantity, the envelopes should return to their original position, and the coëfficients of attractive and repulsive wave actions to their original value, and the molecules would return to their original relative positions; but in fact a portion of this dense ether will be urged outward between the atoms of the envelopes, and so when the recoil comes on, the

* See this Journal, July, 1864, p. 68, and May, 1872, p. 338.

† A paper embodying the principal results obtained in the application of the tests here referred to, was read before the National Academy of Sciences at the meeting in April last.

envelopes may fail to reach their original distance from the central atoms. The dimensions of the molecules, as a whole, may thus be permanently diminished, and, in consequence, the distance between the centers of contiguous molecules at which the opposing molecular actions counterbalance each other be permanently less. The coëfficients n and m (eq. 1) should also be more or less altered, and thus the neutral distance x between the contiguous envelopes at which the effective force f becomes zero, should vary. From the combined operation of these two causes, the relative positions of equilibrium of the molecules should be more or less altered. If a force of tension be applied to the body, a permanent change of an opposite character may ensue.

It still remains to be seen how far the molecular theory that has been set forth, can be reconciled with chemical facts. This question opens too wide a field for present discussion even in the most cursory manner, but a word or two ought to be said to obviate the objection that may at once occur to the reader as fatal to the theory, viz: that the absolute invariability of atoms is established by chemical facts. Strictly speaking, these facts only show the weight of the atoms to be invariable, and that they exhibit the same chemical properties whenever the relations to other atoms are the same, and also in certain cases (e. g. solution) over a certain range of variation in such relations; provided, also, the operation of the physical agents on them is the same. But this does not preclude the supposition that large variations of their mechanical state may occur while the atoms are under different mechanical and physical relations. It may be added that the received molecular formulas of substances would still remain the same, but would have a different physical interpretation. The hypothesis of the breaking up of complex molecules and the formation of new ones, would be replaced by the simple conception of the contraction or expansion of molecular envelopes, with attendant variations of the volume of the mass, and in the physical and chemical properties of the ultimate molecules, which now play the part of "chemical atoms." In gaseous compounds the number of atoms specified in the molecular formula of the compound, would represent the proportionate degree of condensation of the gaseous mixture. Thus, when two volumes of hydrogen are mixed with one volume of oxygen, and by the electric spark are made to combine, the mixed gases would be condensed, by reason of a condensation of all the molecular envelopes, and thus a diminution in the size of the effective molecules, into a space two-thirds that occupied by the mixture before the combination. The elementary volume of the mass would contain two ultimate molecules ("chemical atoms")

of hydrogen, and one of oxygen, just as the "molecular volume," in the received chemical theory, contains these atoms.

If we contemplate this general conception of chemical phenomena, deducible from our general molecular theory, simply in the light of a representative scheme, it must be admitted to be far simpler than the received theory; which is, for the most part, only a scheme of hypothetical transformations supposed to be in some inexplicable way effected by a force of "affinity" or "chemism." For it regards the molecule and "chemical atom" as having a similar physical constitution, and attributes all changes of chemical properties occurring in such molecules to contractions or expansions of their ethereal envelopes, and attendant variations in their active forces, under the operation of the molecular forces and physical agents. If it should hereafter be made apparent that the mechanical relations of *dissimilar* ultimate molecules may in fact be such that changes in the dimensions and effective forces of the molecules may supervene, and that a special force of attraction may come into operation when two such molecules come into juxtaposition, it will be seen that a rational basis is offered for a physical theory of chemical phenomena.

Yale College, Oct. 25, 1878.

ART. XXII.—*Möbius on Eozoon Canadense;** by J. W. DAWSON, LL.D., F.R.S.

Eozoon Canadense has, since the first announcement of its discovery by Logan in 1859, attracted much attention, and has been very thoroughly investigated and discussed, and at present its organic character is generally admitted. Still its claims are ever and anon disputed, and as fast as one opponent is disposed of, another appears. This is in great part due to the fact that so few scientific men are in a position fully to appreciate the evidence respecting it. Geologists and mineralogists look upon it with suspicion, partly on account of the great age and crystalline structure of the rocks in which it occurs, partly because it is associated with the protean and disputed mineral Serpentine, which some regard as eruptive, some as metamorphic, some as pseudomorphic, while few have had enough experience to enable them to understand the difference between those serpentines which occur in limestones, and in such relations as to prove their contemporaneous deposition, and those which may have resulted from the hydration of olivine or

* Der Bau des Eozoon Canadense, von Karl Möbius, Professor der Zoologie in Kiel. Palæontographica, Band xxv.

similar changes. Only a few also have learned that *Eozoon* is only sometimes associated with serpentine, but that it occurs also mineralized with loganite, pyroxene, dolomite, or even earthy limestone, though the serpentinous specimens have attracted the most attention, owing to their beauty and abundance in certain localities. The biologists on the other hand, even those who are somewhat familiar wtth foraminiferal organisms, are little acquainted with the appearance of these when mineralized with silicates, traversed with minute mineral veins, faulted, crushed and partly defaced, as is the case with most specimens of *Eozoon.* Nor are they willing to admit the possibility that these ancient organisms may have presented a much more generalized and less definite structure than their modern successors. Worse, perhaps, than all these, is the circumstance that dealers and injudicious amateurs have intervened, and have circulated specimens of *Eozoon*, in which the structure is too imperfectly preserved to admit of its recognition, or even mere fragments of serpentinous limestone, without any structure whatever. I have seen in the collections of dealers and even in public museums, specimens labelled "*Eozoon Canadense*" which have as little claim to that designation as a chip of limestone has to be called a coral or a crinoid.

The memoir of Professor Möbius affords illustrations of some of these difficulties in the study of *Eozoon.* Professor Möbius is a zoologist, a good microscopist, fairly acquainted with modern foraminifera, and a conscientious observer; but he has had no means of knowing the geological relations and mode of occurrence of *Eozoon*, and he has had access merely to a limited number of specimens mineralized with serpentine. These he has elaborately studied, and has made careful drawings of portions of their structures, and has described these with some degree of accuracy; and his memoir has been profusely illustrated with figures on a large scale. This, and the fact of the memoir appearing where it does, convey the impression of an exhaustive study of the subject, and since the conclusion is adverse to the organic character of *Eozoon*, this paper may be expected, in the opinion of many not fully acquainted with the evidence, to be regarded as a final decision against its animal nature. Yet, however commendable the researches of Möbius may be, when viewed as the studies of a naturalist desirous of satisfying himself on the evidence of the material he may have at command, they furnish only another illustration of partial and imperfect investigation, quite unreliable as a verdict on the questions in hand. The following considerations will serve to indicate the weak points of the memoir.

1. A number of errors and omissions arise from want of study of the fossil *in situ*, and from want of acquaintance with

its various states of preservation. Trivial errors of this kind are his referring to my photograph in Plate III, of the "Dawn of Life," as if it were natural size, and his stating that the larger specimens have fifty laminæ, whereas they often have more than an hundred. More important is his failing to appreciate aright the occurrence of *Eozoon* in certain layers of regularly bedded limestones, the rounded or club-shaped forms of the more perfect specimens, the manner in which the layers become confluent at the edges of the forms, as described by Sir W. E. Logan and myself, or the amount of crushing and fracture which most of the specimens exhibit. Thus he fails to convey any adequate idea of the Stromatoporoid forms and mode of occurrence of the organism, or indeed of its general character and probable mode of growth. Farther he treats it from the first as a mere laminated aggregate of calcite and serpentine, without reference to its occurrence in any other state, and also without reference to the fragmental limestones in part made up of its remains. He objects strongly to the want of definiteness of form and distribution in the chambers and connecting passages, without making allowance for defects of preservation, or mentioning the similar want of defined form in some *Stromatoporæ*. He admits, however, that the modern *Carpenteria* and its allies are in some respects equally indefinite. He farther objects to the impossibility of detecting regular primary chambers like those in modern foraminifera, but seems not to be aware that, as I have recently shown, some *Stromatoporæ* originate in a vesicular, irregular mass of cells, and that in *Loftusia*, both the Eocene *L. Persica*, and the Carboniferous *L. Columbiana*, the primary chamber is represented by a merely cancellated nucleus.*

2. With reference to the finely tubulated proper wall of Eozoon, he has fallen into an error scarcely excusable in an observer of his experience, except on the plea of insufficient access to specimens. He confounds the proper wall with the chrysotile veins traversing many of the specimens, and obviously more recent than the bodies whose fissures they fill. That he does so is apparent from his stating that the proper-wall structure sometimes crosses the bands of serpentine and calcite, and also that it presents a series of parallel four-sided prisms, whereas, when at all perfectly preserved, it shows a series of cylindrical threads penetrating a calcite wall. That some of his specimens have contained the proper wall fairly preserved is obvious from his own figures, in which it is possible to recognize both this structure and chrysotile veins, though confounded by him under the same designation. He objects, somewhat naïvely, that many of the chambers fail to exhibit

* See Journal of London Geol. Soc., January, 1878.

this nummuline wall, and that it sometimes presents a ragged appearance or is altogether opaque. In point of fact it can appear distinctly, either in decalcified specimens or in slices, only when the minute tubes are filled with some substance optically distinguishable from calcite, or not acted on by dilute acid. When the proper wall is merely calcareous (and I have specimens showing that it is often in this state, and without any serpentine in its pores), its structure is ordinarily invisible, and it is the same when the calcareous skeleton has from any cause lost its transparency or has been replaced by some other mineral substance. Even in thickish slices, the tubes, though filled with serpentine, may be so piled on one another as to be indistinct. All this may be seen in Tertiary *Nummulites*. When wholly calcareous their tubulation is often quite invisible, and when imperfectly injected with glauconite or other silicates, they often present a very irregular appearance. If Professor Möbius will study the Nummulites injected with glauconite from Kempten,* Bavaria, in addition to the casts of *Polystomella* from the Ægean to which he refers, he will be better able to appreciate these points. It may be worth repeating here that, in examining the original specimens of Eozoon, I did not recognize the proper wall. I did not doubt that it must have existed in some form, since I could easily detect the canals in the supplemental skeleton; but I did not wonder at its non-appearance, knowing the chances against its preservation in a recognizable form. Its discovery was due to the subsequent investigations of Dr. Carpenter.†

3. To the canal system, Professor Möbius does more justice, and admits its great resemblance to the forms of this structure in modern *Foraminifera*. This indeed appears from his own figures, as will be seen from the fac-simile tracings reproduced here, figs. 1, 2, 3 and 4, which well show how wonderfully this structure has been preserved, and how nearly it resembles the similar parts of modern *Foraminifera*. He thinks, however, that these round and regularly branching forms are rather exceptional, which is a mistake; though it is true that the sections of the larger canals are often somewhat flattened, and that they become flat where they branch. They are also sometimes altered by the vicinity of veinlets or fractures, or by minute mineral segregations in the surrounding calcite, accidents to which all similar structures in fossils are liable. Another

*I am indebted to Dr. Otto Hahn for specimens of these most interesting fossils.

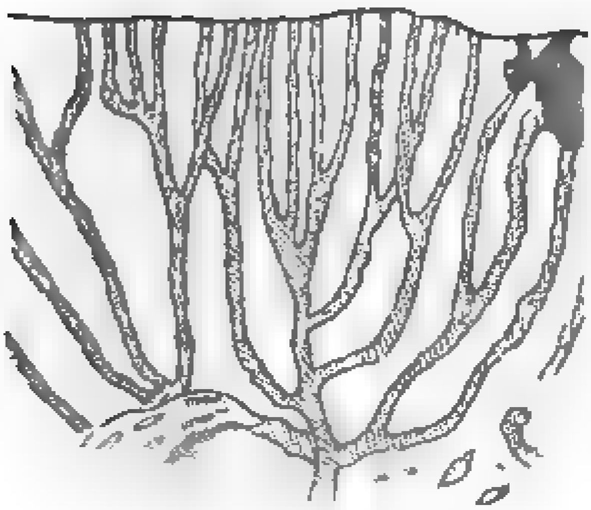
† It may deserve mention here that the Carboniferous *Fusulina* very rarely shows its tubulated wall, and that Dr. Carpenter had maintained its Nummuline affinities before he obtained specimens showing this particular structure. Structures so delicate as these are indeed only preserved exceptionally in fossil specimens.

objection, not original with him, is derived from their unequal dimensions. It is true that they are very unequal in size, but there is some definiteness about this. They are larger in the thicker and earlier formed layers, smaller or even wanting in the thinner and more superficial. In some slices the thicker trunks only are preserved, the slender branches having been filled with dolomite or calcite. It is difficult, also, to obtain, in any slice or any surface, the whole of a group of canals.* Farther, as I have shown, the thick canals sometimes give off groups of very minute tubes from their sides, so that the coarser and finer canals appear intermixed. These appearances are by no means at variance with what we know in other organic structures. Another objection is taken to the direction of the canals, as not being transverse to the laminæ but oblique. This, however, may be dismissed, since Möbius has of course to admit that it is not unusual in modern *Foraminifera*. It may be added that some of the appearances which puzzled Möbius, and which are represented in his figures, evidently arise from fractures displacing parts of groups of canals, and from the apparently sudden truncation of these at points where the serpentine filling gives place to calcite. It would also have been well if he had studied the canal systems of those *Stromatoporæ* which have a secondary or supplemental skeleton, as *Cœnostroma* and *Caunopora*. In illustration of this I give in fig. 5 a group of these canals from a recent paper of my own.†

4. A fatal defect in the mode of treatment pursued by Möbius is that he regards each of the structures separately, and does not sufficiently consider their cumulative force when taken together. In this aspect, the case of *Eozoon* may be presented thus: (1.) It occurs in certain layers of widely distributed limestones, evidently of aqueous origin, and on other grounds presumably organic. (2.) Its general form, lamination and chambers, resemble those of the Silurian *Stromatopora* and its allies, and of such modern sessile foraminifera as *Carpenteria* and *Polytrema*. (3.) It shows under the microscope a tubulated proper wall similar to that of the Nummulites, though of even finer texture. (4.) It shows also in the thicker layers a secondary or supplemental skeleton with canals. (5.) These forms appear more or less perfectly in specimens mineralized with very different substances. (6.) The structures of *Eozoon* are of such generalized character as might be expected in a very early Protozoan. (7.) It has been found in various parts of the world under very similar forms, and in beds approximately of the same geological horizon. (8.) It may be

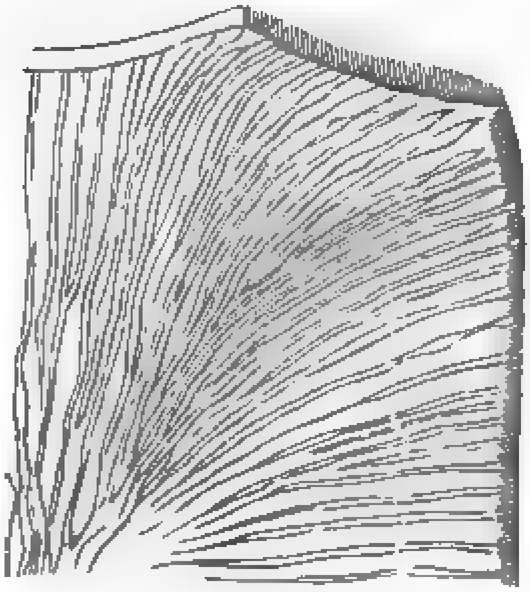
* I have succeeded best in this by etching the surface of broken specimens.
† Journal of London Geological Society, January, 1878.

1.



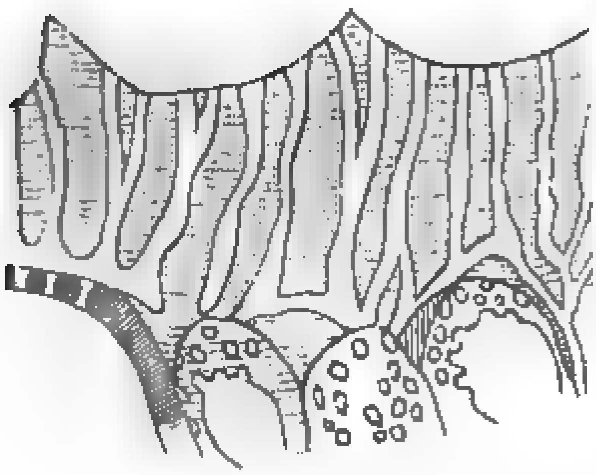
Canals of *Eozoon* (after Möbius).

2.



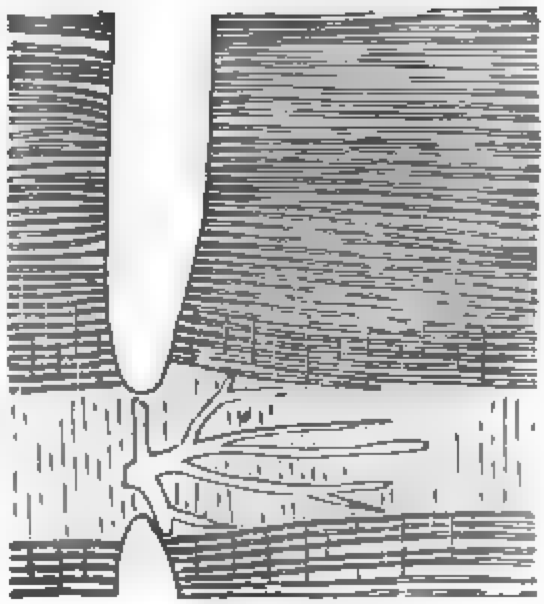
Finer canals of *Eozoon* (after Möbius).

3.



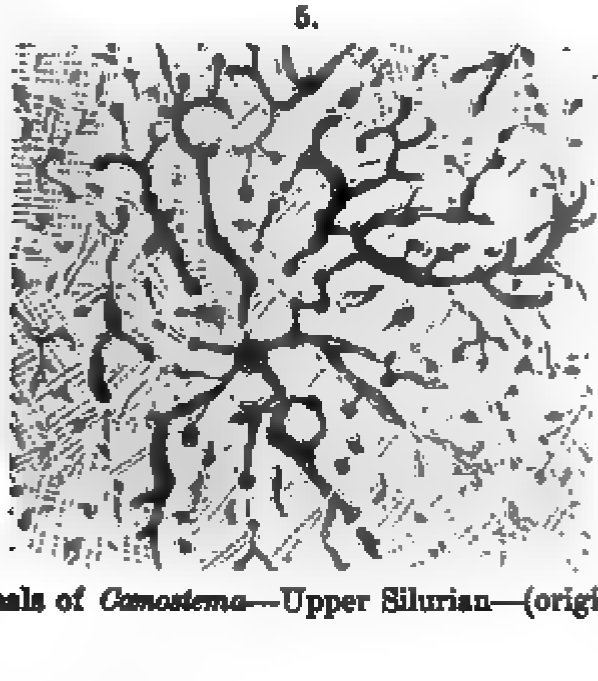
Canals of modern *Calcarina* (after Möbius).

4.



Canals and Tubule of Tertiary *Nummulina* (after Möbius).

5.



Canals of *Cænostema*—Upper Silurian—(original).

added, though perhaps not as an argument, that the discovery of *Eozoon* affords a rational mode of explaining the immense development of limestones in the Laurentian age; and on the other hand that the various attempts which have been made to account for the structures of *Eozoon* on other hypotheses than that of organic origin have not been satisfactory to chemists or mineralogists, as Dr. Hunt has very well shown.

Professor Möbius, in summing up the evidence, hints that Dr. Carpenter and myself have leaned to a subjective treatment of *Eozoon*, representing its structure in a somewhat idealized manner. In answer to this it is necessary only to say that we have given photographs, nature-prints and camera tracings of specimens actually in our possession. We have not thought it desirable to figure the most imperfect or badly preserved specimens, though we have taken pains to explain the nature and causes of such defects. Of course, when attempts at restoration have been made, these must be taken as to some extent conjectural; but so far as these have been attempted they have consisted merely in the effort to eliminate the accidental conditions of fossilized bodies, and to present the organism in its original perfection. Such restorations are not to be taken as evidence, but only as illustrations to enable the facts to be more easily understood. It is to be observed, however, that in the study of such fossils as *Eozoon*, the observer must expect that only a small proportion of his specimens will show the structures with any approach to perfection, and that comparison of many specimens prepared in different ways may be necessary in order to understand any particular feature. A single figure or a short description may thus represent the results of days spent in the field in collecting, of careful examination and selection of the specimens, of the cutting of many slices in different directions, and of much study of these with different powers and modes of illumination. My own collection contains hundreds of preparations of *Eozoon*, each of which represents perhaps hours of labor and study, and each of which throws some light more or less important on some feature of structure. The results of labor of this kind are unfortunately very liable to be regarded as subjective rather than objective by those who arrive at conclusions in easier ways.

Taken with the above cautions and explanations, the memoir of Professor Möbius may be regarded as an interesting and useful illustration of the structures of Eozoon, though from a point of view somewhat too limited to be wholly satisfactory.

Art. XXIII.—*The Magnetic Storm of May* 14, 1878, *observed in North America.*

[Communicated by Carlile P. Patterson, Superintendent United States Coast and Geodetic Survey.]

The extensive magnetic disturbance of May 14, 1878, of which accounts have been given in Nature,* and which was observed in China, Australia and England, also made its record in North America at our magnetic observatory, established at Madison, Wisconsin, in the winter of 1876–1877. This observatory is in latitude 43° 04′ 29″·5, and in longitude $5^h\ 57^m\ 36^s{\cdot}5$ west of Greenwich; in it are mounted a set of Brooke's Magnetographs, and daily photographic traces of the changes in magnetic declination and in the horizontal and vertical forces have been produced since March, 1877, and are intended to be kept up for some years. The declination traces for several days preceding the 14th were normal, but about midnight May 13–14, a series of disturbances commenced consisting in part of some large oscillations to the eastward and westward, and in part of a great number of small and rapid oscillations. The characteristic features of the trace may be given as follows:

	Madison mean time. d. h. m.	Greenwich mean time. d. h. m.
The disturbance in *declination* commenced about	14 0 00 A. M.	14 5 58 A. M.
{ A principal westerly† extreme reached	1 05 "	7 03 "
{ A principal easterly extreme reached	2 36 "	8 34 "

Range of motion 16′·5; after this a series of smaller oscillations continue to past noon.

	d. h. m.	d. h. m.
A maximum westerly position is reached about	0 16 P. M.	6 14 P. M.
And an easterly extreme at	0 53 "	6 51 "
Extreme westerly deflection at	3 26 "	9 24 "
{ A sharp motion to the eastward commences at	5 40 "	11 38 "
{ A principal easterly extreme reached at	6 24 "	15 0 22 A. M.

Range of motion of principal disturbance 31′·7.

There is also a westerly extreme about	7 10 "	1 08 "
And an easterly extreme about	9 16 "	3 14 "

After 10 P. M. the irregularities gradually subside.

Last extreme easterly position	15 1 10 A. M.	7 08 "

It will be noticed that at the Greenwich observatory the storm commenced on May 14, at $6^h\ 05^m$ A. M., at Stonyhurst observatory at $6^h\ 04^m$, at Zi-ka-wei, near Changhai, also at $6^h\ 04^m$ (Gr. time), and at Melbourne supposed at $6^h\ 20^m$; the storm may therefore be taken as simultaneous at these places. At

* Vol. xviii, Nos. 467, 468, 469. † Referring to north end of the magnet.

Greenwich the north end of the needle moved eastward between 6 and 9 A. M., but at Madison the general motion was westerly; again the sharp deflection commencing at 5^h 40^m Mad. time (11^h 38^m P. M. Gr. time) was to the *eastward* at Madison, and to the westward after 11^h 45^m at Greenwich, thus deflecting the magnets in opposite directions.

The northern component of the *horizontal* force was sharply affected at Madison, the force diminishing at 14^d 0^h 05^m A. M., Madison time, 14^d 6^h 03^m A. M., Greenwich time. The disturbance continued, but between $2\frac{1}{2}$ and $7\frac{1}{2}$ A. M., the trace is too indistinct to be read; the small oscillations continue to about 11^h 45^m, when they become superseded by a series of larger waves culminating in a maximum extreme at 2^h 30^m P. M., Madison time, 8^h 28^m P. M., Greenwich time, and a minimum at 3^h 58^m P. M., Madison time, 9^h 56^m P. M., Greenwich time. The large disturbances continue till about 10^h 20^m P. M., having reached a maximum extreme about 4^h 50^m P. M., Madison time, 10^h 48^m P. M., Greenwich time, and a minimum extreme at 9^h 03^m P. M., Madison time; 15^d 3^h 01^m A. M., Greenwich time. Range between maximum at 2^h 30^m, and minimum at 9^h 03^m, $\frac{1}{114}$ of the horizontal force, nearly. In the Greenwich account it is stated "the first start in the trace of the declination magnet at 18^h 05^m (Astr. Rec.) is most distinct." Now within two minutes of this time occurs the first and sharpest deflection in our horizontal force trace at Madison, thus marking distinctly the commencement and simultaneousness of the storm.

The disturbance in the *vertical* force commenced about May 14, 1^h 10^m A. M. (7^h 08^m Gr. time), and terminated about 3^h 30^m A.M.; between this time and 5^h 45^m P. M., the trace was smooth, but between 5^h 45^m and 6^h 45^m a sharp deflection took place in the opposite direction, the maximum force occurring at 6^h 11^m P.M. (May 15, 0^h 09^m A. M. Gr. time), the deflection or increase amounted to $\frac{1}{923}$ of the vertical force. The vertical force trace did not exhibit any of the tremulous motion noticed in the other two curves.

I may state that a description of the Madison magnetic observatory, together with the discussion of the first year's observations and results, is nearly ready in manuscript for publication.

CHAS. A. SCHOTT,
Assistant C. and G. S. in charge Observatory.

Coast Survey Office, Washington, D. C., Jan. 6, 1879.

ART. XXIV.—*On the Flocculation of Particles, and its Physical and Technical Bearings;* by EUGENE W. HILGARD, of the University of California.

I HAVE heretofore (this Journal, Oct. and Nov., 1873) discussed, casually rather than directly, the tendency of small particles to form, under the influence of a moderate agitation, granular aggregates or compound particles of larger size, opposing to mechanical disintegration more or less resistance, according to the circumstances of temperature and moisture. Some discussions since made, and more especially that of Professor S. W. Johnson, on the Mechanical Effects of Tillage,* appear to me to render desirable a more detailed consideration of the various bearings of this phenomenon, which, despite its simplicity, and obviousness in every-day life, seems not to have received all the attention it deserves. This is strikingly exemplified in the modes of experimentation and the more or less contradictory results obtained by different observers—Von Klenze, Haberlandt, Ad. Mayer, Nessler, and others who have studied the capillary relations of soils to water. In comparing the effects of "packing" and "loosening" of powders and soils upon their relations to water, it makes a material difference whether the material used was dry, damp or wet, and whether or not the soil had been previously under tillage for some length of time. Again, Johnson seems to incline to attribute to the flocculation of the *clay* in soils, by various agencies, effects which, I think, clearly belong to all small particles as such.

Perhaps the best fundamental experiment (which can be neatly projected on a screen by the beam of a magic lantern) is the one described in my previous paper (loc. cit., p. 290). A sediment consisting of granules of the uniform hydraulic value of 1^{mm} per second, is introduced into an ordinary conic-cylindrical elutriating tube, placed vertically, in which the current of water entering at the small orifice below, alone performs the stirring-up needed to keep the sediment from settling down. If now a current of water be turned on, corresponding to a velocity *below* that of 1^{mm} at the mouth of the tube, of course none of the sediment can pass out of the upper end, but it will be kept circulating in the conical portion, by a current going upward in the axis of the tube, and downward on the sloping sides of the cone. If this be kept up for ten or fifteen minutes, and then the velocity gradually increased, it will be found that scarcely any of the sediment will pass off, either at the

* Rep. Conn. Exp. Station for 1877.

velocity corresponding to its true hydraulic value, or even at one four or five times higher; the cause being that its single grains have coalesced or "flocculated" into compound grains of from five to thirty or more of the original ones, thus forming in effect a very coarse sediment of roundish masses. When these are allowed to settle, it will be seen that this altered sediment occupies a very much larger space than did the original single-grain sediment, in consequence of the large vacant spaces left between the aggregate-grains; the relation between the two being somewhat like that between gunpowder dust and coarse blasting powder.

If now the coarse sediment be violently stirred by shaking up, or if it be boiled even lightly, the heavy masses disappear, the water becomes uniformly turbid, and after the proper time of quiescence, a thin horizontal layer of single-grain sediment is formed at the bottom of the vessel.

There is nothing very remarkable or new in this experiment; every chemist knows the phenomena it exhibits from every-day experience, and acts upon it in the gentle stirring given to liquids in which precipitates just forming are desired to flocculate. Every geologist has seen the flocculent aggregate-granules rolled along the bottom by a depositing current, and has noticed the rapid clearing of the gentle stream after it has been rendered turbid by stirring; while quiescent pools *in the same material* have remained turbid for some length of time. The experiment with the elutriator-tube, however, is well adapted to the demonstration of the following laws governing the formation of aggregates of immersed particles:

1. The tendency to flocculation is roughly in inverse ratio to the size of the particles. I have already stated (loc. cit., p. 291) that with quartz grains it practically ceases when their diameter exceeds about $0{\cdot}2^{mm}$, or 8^{mm} hydraulic value. It goes without saying that the number of particles that may cohere into one mass, follows substantially the same law. Sediment of $0{\cdot}25^{mm}$ hydraulic value, will sometimes form large masses, like snow flakes, on the sides of the elutriator-tube.

2. The degree of agitation which will resolve the aggregates into single grains, is (roughly) inversely as the size of the particles; or more properly, perhaps, inversely as their hydraulic value.

3. The tendency to flocculation varies inversely as the temperature. In water near the boiling point it is very slight; so strikingly less, that at one time I seriously contemplated the use of such water in the mechanical analysis of soils, in lieu of the mechanical stirring. The difficulties of construction and manipulation of course render this method undesirable, even if it were altogether efficient.

4. The presence of alcohol, ether, and of *caustic* or *carbonated alkalies*, materially diminishes the tendency to flocculation; while the presence of acids and neutral salts seems to increase it.

5. As between sediments of equal hydraulic value but different density, the tendency to flocculation seems to be greater with the less dense particles.

My object being, at the time, not so much the determination of a question of abstract physics, but the finding of an accurate and practicable method of mechanical soil-analysis, I have not pursued farther the interesting points suggested by 4 and 5. The observations made, however, rendered quite obvious a close relation between the capillary properties of liquids and the flocculative tendency of sediments suspended in them. Just what this relation is, must be determined by farther experiment; nor will I undertake to discuss at this time what is the precise nature of the attraction that causes the formation of these flocculated aggregates, and when formed holds them together. Regarding the single particles as irregular spheroids, each of which can, at best, come in contact at three points with any other particle, it cannot be mere surface adhesion independent of the liquid; and the particles being submerged, there is no meniscus to create an adhesive tension. Since experiment shows that the flocculative tendency is measurably governed by the cohesion-coëfficient of the liquid, it seems necessary to assume that capillary films of the latter interposed between the surfaces of solids, *do* create a considerable adhesive tension even in the absence of a meniscus; an assumption that would seem to be rendered necessary also by the enormous increase of adhesion caused by the interposition of a solid film of liquid between plane plates, even when submerged, as compared with that of, e. g., two watch glasses adhering only by their wetted edges, with two concentric circles of menisci. *A priori*, it is to be supposed that the surface tension known to exist between two liquid surfaces, must exist, and exert a corresponding influence between the surfaces of solids and liquids, apart from any meniscal action. I am unable to find that any exhaustive investigation of this particular phase of the subject of molecular attraction has as yet been made.

It is of course to be expected, that the adhesion of the particles constituting one of these floccules will be very materially increased whenever the formation of menisci between them becomes possible by the removal of the general liquid mass. Suppose one of the floccules to be "stranded," it will in the first place remain immersed in a sensibly spherical drop of liquid. As this liquid evaporates, the spherical surface will become pitted with menisci forming between the single projecting

particles; and as these menisci diminish their radius by still farther evaporation, the force with which they hold the particles together will increase, until it reaches a maximum, the position of which (expressed in the liquid-percentage of the mass) must be sensibly a function of the size of the constituent particles. As the evaporation progresses beyond this point of maximum, the adhesion of the constituent particles must diminish by reason of the disappearance of the smaller menisci; and when finally the point is reached when liquid water ceases to exist between the surfaces, the slightest touch, or sometimes even the weight of the particles themselves, will cause a complete dissolution of the floccule, which then flattens down into a pile of single granules.

All this can readily be observed by any one in the progress of a mechanical soil analysis; provided only that the complete separation of the clay from the siliceous sediments has been previously accomplished in the manner set forth in my former paper. The presence of flocculated or coagulated clay modifies the phenomena, in so far as it tends to hold the floccules together under circumstances that in its absence would have caused a complete collapse.

I now proceed to discuss some of the obvious bearings of the phenomenon of flocculation upon natural as well as artificial processes.

First, as regards the formation of aqueous deposits, it is obvious that it is but very rarely that they can be deposited otherwise than in a flocculated condition. As a rule, the water cannot assort in accordance with their individual hydraulic value, any sediments below that of 8^{mm} per second, or about $0{\cdot}2^{mm}$ diameter; and the complex particles thus formed are deposited along with single ones of much higher hydraulic value. The deposition of such an intractable substance as "pure clay" would be, as well as that of any one sediment of very limited range as to size or hydraulic value, is thus practically impossible, save under very exceptional circumstances. Were this otherwise, the local occurrence of soils and rocks of extreme character, both as to chemical and mechanical composition, would be much more frequent than is actually the case.

The fact that, as a consequence of known processes in the formation of aqueous deposits, the latter must be considered as constituted of compound spheroid granules, at once determines the view of Tyndall regarding the cause of slaty cleavage by compression, to be the true one, as against that of Sorby. Yet Tyndall, while assuming such structure to exist, fails to assign any definite cause, outside of crystalline masses. It would be interesting to make the counter-test, and prove that when (as can readily be done) the flocculated structure is destroyed

previous to the application of pressure, slaty structure does not result, either at all, or in as marked a degree. I hope to make this experiment before long.

The destruction of the floccules is effected by what is known in the arts as the tamping or "puddling" of earth or clay. It is the result of violent agitation with water, or of kneading, boiling, or finally, to a certain extent, of freezing. All these agencies are employed by the workers in clay for the purpose of increasing plasticity, which depends essentially upon the finest possible condition of the material to be worked: for when it is in a flocculent or granular condition, it assumes more or less the properties of sand.

The latter fact can be most strikingly shown in the following manner: Let any clay or clay soil be worked into a plastic paste with water and then dried; the result will be a mass of almost stony hardness. Add to the same paste about 0·5 per cent of caustic lime, which substance (as shown by Schlœsing and myself) possesses in an eminent degree the property of coagulating clay into floccules. The diminution of plasticity will be obvious at once, even in the wet condition; and upon drying, the mass will fall into a pile of crumbs upon a mere touch, or dropping it on the floor—a striking lecture experiment, as well as a convincing illustration of the effect of liming upon clay soils, in rendering them "warmer" and more readily tilled. I found that bubbling carbonic acid gas through a magma of the limed clay for twenty-four hours, when all alkaline reaction had disappeared, had failed to restore the plasticity even when, after drying, the carbonate solution had been destroyed. This agrees with the experience of farmers that the "lightening" effect of a liming continues for years to be very manifest, and is never entirely lost. It is well known that marling produces similar but weaker effects; and the same can be observed wherever one and the same clay soil is partially subject to washings from limestone hills, or to the admixture of underlying calcareous strata. Schlœsing's experiments on the efficacy of lime water in coagulating clay water, show its effect to exceed greatly that of any other calcium compounds; and so far as my experiments go, I find those of no other element approaching, in this respect, those of calcium. In this connection Dr. John LeConte's remarks on the exceptional transparency of calcareous waters in Florida (Proc. Am. Assoc. Adv. Sci., 1860, p. 33) should be called to mind.

Were any farther proof needed regarding the nature of the effects of tillage upon soils, this lime experiment would supply it. *It is the loosely flocculated aggregation of the soil particles which constitutes good tilth*, as against the partially "tamped" condition which results from the mechanical action of rains

and (in silt soils) of drying. Tillage acts not merely, as Professor Johnson says (On some Reasons for Tillage, Rep. Sec'y, Conn. Board of Agr., 1877-8): "by lifting up masses of soil, turning them and letting them fall so that the close contact produced by rest (?) and moving water is broken, and the grains of sand and the minute aggregations of loam are brought into new positions with regard to each other, and to greater distances from each other." These "new positions" and "greater distances" are brought about and maintained by the phenomenon of flocculation, by the formation of compound crumbs ("ackerkrume"), which can be readily seen and compared with the partially "tamped" soil on the land side, in any furrow made in well-tilled cultivated soil; and they relate to each other, both as to bulk and permeability, in mass, somewhat as powdered lead would to bird-shot. If this be the correct view, mere *rest* cannot, in general, produce any compacting influence on soils, such as is claimed (loc. cit.) by Professor Johnson; and I think the proof that it is innocent of any such action is found in the case of any virgin soil in forests, where the protecting covering of leaves assures the most absolute rest to the soil for centuries, and where, nevertheless, it is always in such tilth as our best-tilled fields might envy.

There is one class of soils, nevertheless, in which "rest" may be said to produce compacting, to wit: those consisting of siliceous silt with not clay enough to maintain them in position after drying; so that the loose arches of the floccules collapse by their own weight, or by the least shocks. This happens not unfrequently in river-sediment soils; and the curious result is that they are injured by plowing when very *dry*, in the same way that clayey soils are when plowed too *wet*. In both cases the effect is to destroy the floccules and produce a single-grain or tamped structure, which it requires several seasons' tillage to rectify. In the case of "beating" rains, the hardening effect upon the surface is of course due to the mechanical destruction of the floccules, followed by the infiltration with "clay water," which, in drying, acts as a hardening cement.

In some soils the point of maximum cohesion of the floccules, and consequently the tendency to maximum flocculation, lies between very narrow limits; as the farmer says, they have to be plowed when "just right," or not at all, on pains of injuring their tilth for years. I find among these not only the clay soils proper, but another class consisting of uniformly fine silts (chiefly 1^{mm} hydraulic value, and below) with but very little clay; which, when wet, are said to "work like putty," and when a very little too dry remain cloddy. Those in which the tillage may be done within a wide range of condition as to moisture, are those containing a great variety of sediments of

all sizes; colluvial rather than alluvial, and usually called "loams." The exact conditions of maximum flocculability, however, and the influence exerted thereon by each of the several sediments and their combinations, still remain to be determined; and the task is not a light one.

It is known that the longer a soil has been maintained in perfect tilth, the more difficult it is to "puddle" it by wet plowing. This is doubtless owing to the gradual cementation of the floccules by the soil water; which fixes them, as it were, more or less permanently.

As to the action of frost on soils, it is clear that as the water-menisci within the floccules freeze, the soil must be reduced to its ultimate mechanical elements, held apart by the ice crystals. It is thus readily intelligible why plowing too wet, *after a freeze*, is so much more injurious to tilth than when done after only a rain. But when the thawed soil is allowed first to assume its proper moisture-condition, the newly-formed floccules are of course looser than ever; and in clay and loam soils the most perfect tilth is the result, while *clayless* ones are measurably "*puddled*" *by frost*.

The "ripening" of potter's clay by freezing, boiling, alternate wetting and drying, or finally by thorough working, is obviously based on the same process of "atomization." Not only do these processes destroy the mechanically formed aggregates, but boiling at least, and probably all the rest, serve to reduce the kaolinite ingredient of soils and clays to the amorphous, plastic, diffusible modification. As to boiling, I have succeeded in rendering diffusible and very plastic, the seventy-five per cent of clayey ingredient in a white, chalky pipe clay, resembling kaolin, and which naturally is but very slightly plastic, by boiling for about eighty-five hours. In this case the clay water showed, even after a week's subsidence, a distinctly dotted structure under a power of five hundred diameters, instead of the non-resolvable cloud exhibited by the water from naturally plastic clays. Since lithological evidence proves conclusively that mere soaking in water does not produce the transformation, unless accompanied by mechanical agencies: we can hardly escape the conclusion that the difference between the plastic and non-plastic kaolinite is merely mechanical, and not properly comparable to that between quartz and chalcedony.

In regard to the action of alkaline carbonates in preventing flocculation, and thus rendering tillage difficult or impossible, many of the "alkali soils" of California supply striking examples. The name is popularly applied, almost indiscriminately, to any soil containing such excess of soluble salts of any kind, as to become apparent by efflorescence. Among these, however, the soils impregnated with alkaline carbonates may

generally be recognized by their extreme compactness, and refractoriness under tillage; and by the fact that they usually form "low spots" in the general surface of non-alkaline land, where turbid clay water, dark with dissolved humus, will lie for weeks after the higher land appears dry. I give below the results of the comparative mechanical analysis of two samples of soil, taken within twelve feet of each other, on an alkaline tract in the neighborhood of Stockton, Cal. One of these represents a fertile "ridge" soil, in excellent tilth, lying (naturally) about eighteen inches higher than the soil of the adjacent alkali tract, in which the same soils alternate on hillocks and in depressions, so as to render it impossible to cultivate one without the other. The alkali soil had been plowed, cross-plowed, rolled and harrowed, until the harrow produced no further effect; and the result was a seed-bed of soil clods ranging from the size of a pea to that of a billiard ball, but no tilth. At the same time, portions of the "ridge" soil so treated were reduced to an ashy condition of tilth. Inspection seemed to show that the two soils differ but little in mechanical composition; not nearly enough to account for such difference of tilling qualities. The analyses resulted thus:

STOCKTON SOILS.

	Non-alkaline.	Alkaline.
Clay,	20·8	24·6
Sediment < 0·25^{mm} hydraulic value	32·0	26·1
" 0·25 " "	3·3	3·3
" 0·50 " "	6·6	9·4
" 1·0 " "	5·6	6·2
" 2·0 " "	7·3	6·2
" 4·0 " "	7·5	5·4
" 8·0 " "	5·7	4·8
" 16·0 " "	4·8	4·7
" 32·0 " "	1·5	5·9
" 64·0 " "	1·2	1·1
	96·4	97·7

The only material difference in the mechanical composition of these two soils is in the relative amounts of clay and finest sediment; and this is perhaps more apparent than real, inasmuch as the disintegrating action of the alkali has doubtless been instrumental in bringing out as "clay" in the alkaline soil, a portion of what in the other has remained behind in the finest sediment. Still, as the alkali soil lies close to, and lower than, the tillable soil, and receives its washings, it should contain somewhat more clay than the latter. Taking the results as they are, however, it is clear that the mechanical composition of the alkali soil gives no clue to the cause of its be-

havior under tillage, since a soil containing no more than 24·6 per cent of clay, with all sediments above the finest so evenly distributed, should be classed simply as a "clayey loam."

The dark brown soil-extract, leached from the alkali soil, amounted, after ignition and treatment with carbonic acid, to 0·251 per cent. Of this amount, 0·158 was again soluble, 0·093 remaining behind as earthy salts, etc. The soluble part was constituted thus:

Carbonate of sodium	52·74
Chlorid of sodium	38·08
Sulphate of sodium	13·26
Tri-sodic phosphate	1·83
	100·91

The insoluble part of the aqueous extract gave:

Carbonate of calcium	14·02
Tri-calcic phosphate	5·37
Tri-magnesic phosphate	5·77
Silica (soluble in Na_2CO_3)	24·37
Iron oxides, alumina, and some clay (by difference)	50·47
	100.00

It will be observed that notwithstanding the presence of considerable amounts of neutral sodium and calcium salts, that of about 0·08 per cent of carbonate of sodium was sufficient to render the soil practically untillable. In this case, as well as in that of a very large amount of similar "alkali land" in the state, the application of a sufficient amount of gypsum to decompose the alkaline carbonate, produces a surprising change; which, on the small scale, can be perceived at once, but in the field, naturally requires a season's tillage to become effective as to tilth. It at once prevents, of course, the injury to seeds and growing plants arising from the corrosive action of the alkaline carbonate, which helps to render them unprofitable for culture.

My suggestion of the use of gypsum on soils of this character, not containing enough of soluble salts to render their presence objectionable when neutral, has already been tested in practice with the most satisfactory results. It will be seen that among the soluble salts is a comparatively very large amount of alkaline and earthy phosphates, which (in accordance with Grandeau's researches) follow the humus acids into solution even when the solvent is alkaline. Were the soil to be thorough-drained (as has sometimes been done in order to relieve the excess of salts) these phosphates would be carried off in the drain water. The use of gypsum prevents this loss by rendering the phosphates insoluble together with the humus, albeit in such a finely

divided state as to remain perfectly available to vegetation. The double benefit thus gained manifests itself in the exuberant fertility of the soils so treated. I shall hereafter describe more in detail the very singular features of the California alkali soils, but mention the present as a conspicuous example of the benefits to be derived from an intelligent, direct investigation of soils.

Among the many other cases in which the phenomenon of flocculation comes into play in technical practice, I only mention that of ore extraction by means of solvents. Were the solvent liquid poured on the finely pulverized dry ore, it would permeate it with extreme slowness, and the subsequent washing-out of the solution would be tedious in the extreme. It is therefore the universal practice with all fine ores to dampen them first with an amount of water varying according to the nature and fineness of the ore, and then by stirring or working over, to flocculate them, or, in technical language, to render them "woolly." Care is then taken to prevent the inflow of water from "puddling" the charge by direct impact, and all stirring or concussion whereby the flocculated arrangement of the particles might be broken down, is carefully avoided.

Similarly, of course, the leaching-out the soluble salts from a true "alkali soil" by the ordinary process of percolation, is almost impossible in consequence of the entire absence of flocculation; and can only be accomplished by a long series of decantations followed by evaporation to dryness, extraction of the residue by quiet upward diffusion, and syphoning-off. Even thus, a final correction for clay that has defied both filtration and subsidence, must almost always be made.

ART. XXV.—*Remarks on the Jura-Trias of Western North America;* by C. A. WHITE, Paleontologist to the U. S. Geological Survey.

THE fact is generally known that among North American rocks neither the Jurassic nor Triassic period are any where so well represented as they are in certain parts of Europe. Indeed, until within a few years past it has not been claimed as demonstrated by the presence of characteristic types of fossils that any strata of the western territories of the United States are exactly equivalent with any Triassic strata of Europe, although a certain series, distributed over a large portion of that great western region has been recognized as Jurassic; and also a certain sandstone formation, usually of a red or reddish color, generally present beneath that Jurassic series, has been

very generally referred to the Trias. It is my present purpose to offer some remarks upon these western Mesozoic formations, but not now to consider those strata which are commonly referred to the Triassic period in Connecticut and certain Atlantic States farther south.

Some modification of the views concerning these western formations that have been just indicated was produced, but the elucidation of the question of actual synchronism of these two groups with European strata hardly advanced by the following circumstances. The sandstone formation before referred to, which, from its prevalent color has been often designated as the "Red Beds," had been generally regarded as unfossiliferous, except that some imperfect vertebrate remains and an abundance of silicified wood have been found in its strata; but Dr. Hayden, in 1869, published* the statement that he had found unmistakable Jurassic fossils near the base of this group which until then had been referred to the Trias almost without question. Also, in 1874, Mr. E. E. Howell, then in charge of one of Professor Powell's parties, collected in southern Utah, from the lower portion of the formation in question, several species of invertebrate fossils, some of which, at least, I regard as specifically identical with well-known species which, until then, had been found only in the unquestioned Jurassic strata of the western territories.† As far as this paleontological evidence extended, it seemed to indicate that all the Mesozoic strata of that great region east of western Nevada, and beneath the Dakota group of the Cretaceous series belong to one and the same epoch. The impression however still prevailing that the Triassic period, at least in part, is really represented by the Red Beds, the term Jura-Trias began to be used to designate collectively that formation together with the Jurassic strata above it. This collective designation seems to have met with general approval and, although our knowledge concerning these strata and their equivalents is increasing, it seems advisable to continue it until further investigation shall enable us to fix upon some definite horizon for their separation.

None of the foregoing remarks are intended to apply to the great development of Upper Triassic strata which, as is well known, exist near the western border of the continent. The existence of these strata was first made known in 1864, by the publication of volume I, Paleontology of California; and they were still further described in the lately published volumes of the United States Geological Exploration, 40th Parallel. In both

* See page 11, Geol. Rep. Expl. Yellowstone and Missouri Rivers. By F. V. Hayden, under the direction of Capt. W. F. Raynolds, Corps of Engineers U. S. A. Made in 1860 and published in 1869. 8vo, pamphlet.

† See White's paleontological chapter in Powell's Report on the Geology of the Uinta Mountains, pages 80 and 87.

of these works the contained fossils are fully illustrated and described, and the strata are, by those fossils, referred to the horizon of the St. Cassian, Aussee, and Hallstadt deposits of Europe. Professor Whitney says in the first work just cited: "This great Triassic belt of the Pacific coast has been most fully explored by the survey in the latitude of 40°, and over a width east and west of nearly four degrees of longitude (117° to 121°) . . . . But sufficient paleontological evidence has been obtained to enable us to state that this formation extends from Mexico to British Columbia, and that it occupies a vast area, although much broken up, interrupted by eruptive rocks, and covered in many places by heavy accumulations of volcanic materials."

No fossils, however, as already stated, or at least no invertebrates, were known to exist in any North American strata east of that region which could be confidently referred to the Triassic period, until the autumn of 1877, when a collection was brought in by one of the parties of the United States Geological Survey of the Territories, in charge of Dr. F. V. Hayden, which was found to contain molluscan types that are plainly Triassic. The collection referred to was made by Dr. A. C. Peale, field geologist, from two or three localities in southeastern Idaho, and which, with the other collections of the survey, came into my hands for study. They have, however, only lately received investigation, and their preliminary publication will soon be made in Part I, vol. v, Bull. U. S. Geol. Sur. Terr.

The fossils which have been obtained at numerous localities in different parts of the western territories and referred with little or no question to the Jurassic period are well known; such, for example, as *Pentacrinus asteriscus* Meek and Hayden, *Belemnites densus* M. & H., *Camptonectes bellistriatus* M. & H., *Eumicrotis curta* Hall, *Ostrea strigilecula* White, &c. Wherever in that region a collection of Jurassic (or as they have come to be commonly designated, Jura-Trias) fossils has been made, some one or more of these species has generally been found among them; and the new forms, whenever they have been discovered, have not generally been in excess of those which were previously known, thus suggesting the discovery of no separate horizons. Almost the contrary, however, is the case with the collection from the localities here referred to in southeastern Idaho, because, out of the list of the species obtained there and presently to be mentioned, only three were previously known, and only one (*Eumicrotis curta*) has ever been found associated with well-known Jurassic fossils.

At the principal one of these localities, which is about sixty-five miles north of the southern, and eighteen miles west of the eastern, boundary of Idaho, Dr. Peale found the Jura-Trias

ta in question to be about 3,000 feet in thickness of altering limestones, sandy shales and sandstones, with about 0 feet of Carboniferous strata beneath them, and with ch they are apparently strictly conformable. He found in immediate vicinity no exposures of the Red Beds, which e so generally been referred to the Trias, but he recognd them at some localities only a few miles away; and he is ident that they occupy a position immediately above the ermost strata of the series exposed at the locality here cially referred to. It thus appears that this fossiliferous s, containing true Triassic types, occupies a position beneath comparatively unfossiliferous Red Beds which were so long posed to be the only representatives of the Trias in that great on; and that they separate the former from the well-known assic series. The fossils of this lower series were found at erent horizons within the thickness of 3,000 feet exposed at locality mentioned, the following being a list of them:

Terebratula semisimplex White; 2. *T. augusta* Hall & Whitl?; 3. *Aviculopecten Idahoensis* Meek; 4. *A. Pealei* W.; 5. *A.* s W.: 6. *Eumicrotis curta* Hall; 7. *Meekoceras aplanatum* W.; *M. Mushbachanus* W.; 9. *M. gracilitatus* W.; 10. *Arcestes?* *tus* W.; 11. *A.?*———?

ll except Nos. 2, 3 and 6 of this list are new forms, and have hitherto been found only within that limited area in heastern Idaho. No. 2, which is referred by its authors to Jurassic of Nevada, is doubtfully identified as above. The specimens of No. 3 were obtained from another locality in heastern Idaho several years ago, and doubtless from the e horizon as that of the foregoing list. No. 6 is a common il and has by different geologists been reported from ierous and widely separated Jurassic localities in the west. ed it is at present, by this species alone, that the collection he foregoing list is connected with the well-recognized ssic of that great region.

he Brachiopods and Conchifers of this collection would not e attracted particular attention under the circumstances, but Cephalopods present types which had never been found in erican Jurassic strata, but are clearly Triassic; one of ch was a new generic form. Having recognized the unique acter of this collection, the Triassic type of the Cephalo-, and the fact that although closely related to typical *tites*, one group especially presented some important generic lifications, concerning which I desired the opinion of Pror Alpheus Hyatt, whose excellent and exhaustive labors n this class of fossils are so well known. I therefore sent n to him for examination, and of the two, or perhaps three, eric forms which they embrace he describes one as new,

under the name of *Meekoceras*, and refers the others, doubtfully, because of the imperfection of the specimens, to *Arcestes* Suess.

Now comes an interesting and, in view of the recognized St. Cassian age of the Nevada Trias before referred to, a somewhat unexpected fact. The types of these Cephalopods, as distinctly stated by Professor Hyatt, have close affinities with those of the Muschelkalk or Middle Trias of Europe, and not with those of the St. Cassian, Aussee, and Hallstadt deposits of the European Upper Trias. This fact, however, need not excite especial surprise when it is remembered that the southeastern Idaho locality is about four hundred miles eastward from that of the Nevada Trias; and, furthermore, that the positions which they occupy are respectively adjacent to east and west borders of an extensive area which was above the level of the sea during the whole of Mesozoic time; and which extended from the southern to the northern portion of North America. The deposits of the two regions were therefore never directly continuous, and probably no physical connection of their strata respectively, need be sought for.

With this discovery of a true Triassic fauna east of that long continental area of Mesozoic time, new interest is given to the study of the earlier Mesozoic rocks of the western territories. There are such indications of an intimate faunal relationship between these Triassic strata of southeastern Idaho and the true Jurassic strata of that great western region, that I still prefer to hold to the provisional designation of Jura-Trias for the whole of them. But in view of the great development of the first mentioned strata, although now known only in a limited area, and of the distinctively Triassic facies of its types, especially the Cephalopods, it seems not improbable that we may yet find a physical plane for their separation as Jurassic and Triassic groups respectively.

ART. XXVI.—*On the Illumination of Lines of Molecular Pressure, and the Trajectory of Molecules;* by WILLIAM CROOKES, F.R.S., V.P.C.S.*

Induction Spark through Rarefied Gases.—Dark Space round the Negative Pole.—The author has examined the dark space which appears round the negative pole of an ordinary vacuum-tube when the spark from an induction-coil is passed through it. He describes many experiments with different kinds of poles, a varying intensity of spark, and different gases, and arrives at the following propositions:—

* Abstract of a paper read before the Royal Society, Dec. 5, 1878. (Phil. Mag., Jan., 1879.)

Illumination of Lines of Molecular Pressure.—*a.* Setting up an intense molecular vibration in a disk of metal by electrical means excites a molecular disturbance which affects the surface of the disk and the surrounding gas. With a dense gas the disturbance extends a short distance only from the metal; but as rarefaction continues, the layer of molecular disturbance increases in thickness. In air at a pressure of 0·078 millim. this molecular disturbance extends for at least 8 millims. from the surface of the disk, forming an oblate spheroid around it.

b. The diameter of this dark space varies with the exhaustion, with the kind of gas in which it is produced, with the temperature of the negative pole, and, in a slight degree, with the intensity of the spark. For equal degrees of exhaustion it is greatest in hydrogen and least in carbonic acid, as compared with air.

c. The shape and size of this dark space do not vary with the distance separating the poles, nor (or only very slightly) with alteration of battery-power, nor with intensity of spark. When the power is great the brilliancy of the unoccupied parts of the tube overpowers the dark space, rendering it difficult of observation; but, on careful scrutiny, it may still be seen unchanged in size; nor does it alter even when, with a very faint spark, it is scarcely visible. On still further reduction of the power it fades entirely away, but without change of form.

The author describes numerous experiments, devised to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure or stress, the investigation of which has occupied him for some years.

The Electrical Radiometer.—One of these experiments is as follows:—An ordinary radiometer is made, with aluminium disks for vanes, each disk coated with a film of mica. The fly is supported by a hard steel cup instead of a glass cup; and the needle-point on which it works is connected by means of a wire with a platinum terminal sealed into the glass; at the top of the radiometer-bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction-coil, the movable fly being made the negative pole.

Passing over the phenomena observed at low exhaustions, the author finds that, when connected with the coil, a halo of a velvety violet light forms on the metallic side of the vanes, the mica side remaining dark throughout these experiments. As the pressure diminishes a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and positive rotation commences.

On continuing the exhaustion, the dark space further widens out and appears to flatten itself against the glass, and the rotation becomes very rapid.

When aluminium cups are used for the vanes instead of disks backed with mica, similar appearances are seen. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. On further exhaustion, the dark space on the convex side touches the glass, when positive rotation commences, becoming very rapid as the dark space further increases in size and ultimately flattens against the glass.

Convergence of Molecular Rays to a Focus.—The subject next investigated is the convergence of the lines of force to a focus, as observed with the aluminium cup. As this could not be accomplished during rapid rotation, an instrument was made having the cup-shaped negative pole fixed instead of movable. On exhaustion, the convergence of the lines of force to a focus at the concave side was well observed. When the dark space is very much larger than the cup, it forms an irregular ellipsoid, drawn in toward the focal point. Inside the luminous boundary a focus of dark violet light can be seen converging, and, as the rays diverge on the other side of the focus, spreading beyond the margin of the dark space—the whole appearance being strikingly similar to the rays of the sun reflected from a concave mirror through a foggy atmosphere.

Green Phosphorescent Light of Molecular Impact.—At very high exhaustions the dark space becomes so large that it fills the tube. Careful scrutiny still shows the presence of the dark violet focus; and the part of the glass on which fall the rays diverging from this focus shows a sharply defined spot of greenish-yellow light. On still further exhaustion, and especially if the cup is made positive, the whole bulb becomes beautifully illuminated with greenish-yellow phosphorescent light.

This greenish-yellow phosphorescence, characteristic of high exhaustions, is frequently spoken of in the paper. It must be remembered, however, that the particular color is due to the special kind of soft German glass used. Other kinds of glass produce a different color. The phosphorescence takes place only under the influence of the negative pole. At an exhaustion of 4 M * no light other than this is seen in the apparatus. At 0·9 M the phosphorescence is about at its maximum. When the exhaustion reaches 0·15 M, the spark has a difficulty in passing, and the green light appears occasionally in flashes only. At 0·06 M the vacuum is almost non-conductive; and a spark can be forced through only by increasing

* M signifies the millionths of an atmosphere.

the intensity of the coil and well insulating the tube and wires leading to it. Beyond that exhaustion nothing has been observed.

Focus of Molecular Force.—In an apparatus specially constructed for observing the position of the focus the author found that the focal point of the green phosphorescent light was at the center of curvature, showing that the molecules by which it is produced are projected in a direction normal to the surface of the pole. Before reaching the heat exhaustion for the green light, another focus of blue-violet light is observed; this varies in position, getting further from the pole as the exhaustion increases. In the apparatus described, at an exhaustion of 19·3 M, these two foci are seen simultaneously, the green being at the center of the curvature, while the blue focus is at nearly twice the distance.

Nature of the Green Phosphorescent Light.—The author adduces the following characteristics of the green phosphorescent light, as distinguishing it from the ordinary light observed in vacuum-tubes at low exhaustions:

a. The green focus cannot be seen in the space of the tube, but where the projected beam strikes the glass only.

b. The position of the positive pole in the tube makes scarcely any difference in the direction and intensity of the lines of force which produce the green light. The positive pole may be placed in the tube either at the extremity opposite the negative pole, or below it, or by its side.

c. The spectrum of the green light is a continuous one, most of the red and the higher blue rays being absent; while the spectrum of the light observed in the tube at lower exhaustions is characteristic of the residual gas. No difference can be detected by spectrum-examination in the green light, whether the residual gas be nitrogen, hydrogen, or carbonic acid.

d. The green phosphorescence commences at a different exhaustion in different gases.

e. The viscosity of a gas is almost as persistent a characteristic of its individuality as its spectrum. The author refers to a preliminary note and a diagram* of the variation of viscosity of air, hydrogen, and other gases at exhaustions between 240 M and 0·1 M. From these and other unpublished results, the author finds that the viscosity of a gas undergoes very little diminution between atmospheric pressure and an exhaustion at which the green phosphorescence could be detected. When, however, the spectral and other characteristics of the gas begin to disappear, the viscosity also commences to decline; and at an exhaustion at which the green phosphorescence is most brilliant the viscosity has rapidly sunk to an insignificant amount.

* Proc. Roy. Soc., Nov. 16, 1876, vol. xxv, p. 305.

f. The rays exciting green phosphorescence will not turn a corner in the slightest degree, but radiate from the negative pole in straight lines, casting strong and sharply defined shadows from objects which happen to be in their path. On the other hand, the ordinary luminescence of vacuum-tubes will travel hither and thither along any number of curves and angles.

Projection of Molecular Shadows.—The author next examines the phenomena of shadows cast by the green light. The best and sharpest shadows are cast by flat disks and not by narrow-pointed poles; no green light whatever is seen in the shadow itself, no matter how thin, or whatever may be the substance from which it is thrown.

From these and other experiments, fully described in the paper, he ventures to advance the theory that the induction-spark actually illuminates the lines of molecular pressure caused by the electrical excitement of the negative pole. The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keep back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions.

When the exhaustion is sufficiently high for the mean length of path between successive collisions to be greater than the distance between the fly and the glass, the swiftly moving rebounding molecules spend their force, in part or in whole, on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. The light actually proceeds from the glass, and is caused by fluorescence or phosphorescence on its surface. No light is produced by a mica or quartz screen; and the more fluorescent the material the better the luminosity. Here the consideration arises that the greenish-yellow light is an effect of the direct impact of the molecules in the same electrical state on the surface of the glass. The shadows are not optical, but are molecular shadows revealed only by an ordinary illuminating effect; this is proved by the sharpness of the shadows when projected from a wide pole.

Phosphorescence of Thin Films.—An experiment is next described in which a film of uranium glass, sufficiently thin to show colors of thin plates, is placed in front of a thick plate of the same glass, the whole being closed in a tube with terminals and exhausted to a few millionths of an atmosphere. Of this the following observations are recorded:—

a. The uranium film, being next to the negative pole, casts a strong shadow on the plate.

b. On making contact with the coil, the thin film flashes out suddenly all over its surface with a yellowish phosphorescence, which, however, instantly disappears. The uncovered part of the plate does not become phosphorescent quite suddenly, but the phosphorescence is permanent as long as the coil is kept at work.

c. With an exceedingly faint spark the film remains more luminous than the plate; but on intensifying the spark, the luminosity of the film sinks, and that of the uncovered part of the plate increases.

d. If a single intense spark be suddenly sent though the tube, the film becomes very luminous, while the plate remains dark.

These experiments are conclusive against the phosphorescence being an effect of the radiation of the phosphorogenic ultra-violet light from a thin layer of arrested molecules at the surface of the glass; for were this the case, the film could under no circumstances be superior to the plate.

The momentary phosphorescence and rapid fading of the film prove more than this. The molecular bombardment is too much for the thin film. It responds thereto at first, but immediately gets heated by the impacts, and then ceases to be luminous. The plate, however, being thick, bears the hammering without growing hot enough to lose its power of phosphorescing.

Mechanical Action of Projected Molecules.—When the coil was first turned on, the thin film was driven back at the moment of becoming phosphorescent, showing that an actual material blow had been given by the molecules. Experiments are next described in which this mechanical action is rendered more evident. A small rotating fly, capable of being moved about in any part of an exhausted bulb, is used as an indicator; and by appropriate means the molecular shadow of an aluminium plate is projected along the bulb. Whether entirely in or entirely out of the shadow, the indicator scarcely moves; but when immersed so that one-half is exposed to molecular impact the fly rotates with extreme velocity.

Magnetic Deflection of Lines of Molecular Force.—With this apparatus another phenomenon was investigated. It is found that the stream of molecules whose impact on the glass occasions evolution of light is very sensitive to magnetic influence; and by bringing one pole of an electromagnet, or even of a small permanent magnet, near, the shadow can be twisted to the right or to the left.

When the little indicator was placed entirely within the molecular shadow no movement was produced. As soon, however, as an adjacent electromagnet was excited, the shadow was

twisted half off the indicator, which immediately rotated with great speed.

The Trajectory of Molecules.—The amount of deflection of the stream of molecules forming a shadow is in proportion to the magnetic power employed.

The trajectory of the molecules forming the shadow is curved when under the magnetic influence; the action of the magnet is to twist the trajectory of the molecules round in a direction at an angle to the free path, and to a greater extent as they are nearer the magnet, the direction of twist being that of the electric current passing around the electromagnet.

Laws of Magnetic Deflection.—An apparatus was constructed so that the deflection of a spot of light was used instead of that of a shadow, a horseshoe magnet being placed underneath the negative pole to deflect the trajectory. The action of the north pole being to give the line of molecules a spiral twist one way, and that of the south pole being to twist in the other way the two poles side by side compel the line to move in a straight line up or down, along a plane at right angles to the plane of the magnet and a line joining its poles.

The ray of molecules does not appear to obey Ampère's law, as it would were it a perfectly flexible conductor, joining the negative and the positive pole. The molecules are projected from the negative; but the position of the positive pole—whether in front, at the side, or even behind the negative pole—has no influence on their subsequent behavior, either in producing phosphorescence, or mechanical effects, or in their magnetic deflection. The magnet gives their line of path a spiral twist, greater or less according to its power, but diminishing as the molecules get further off.

Numerous experiments were tried in this apparatus with different gases, and with the magnet in and out of position.

Working with exhausted air it was found that the spot of green phosphorescence on the screen is visible at an exhaustion of 102·6 millim., when the mean free path of the molecules, measured by the thickness of the dark space round the negative pole, is only 12 millims. Hence it follows that a number of molecules sufficient to excite green phosphorescence on the screen are projected the whole distance from the pole to the screen, or 102 millims., without being stopped by collisions.

Alteration of Molecular Velocity.—If we suppose the magnet to be permanently in position, and thus to exert a uniform downward pull on the molecules, we perceive that the trajectory is much curved at low exhaustions, and gets flatter as the exhaustion increases. A flatter trajectory corresponds to a higher velocity. This may arise from one of two conditions: either the initial impulse given by the negative pole is stronger

or the resisting medium is rarer. The latter is probably the true one. The molecules which produce the green phosphorescence must be looked upon as in a state differing from those arrested by frequent collisions. The latter impede the velocity of the free molecules and allow longer time for magnetism to act on them; for, although the deflecting force of magnetism might be expected to increase with the velocity of the molecules, Prof. Stokes has pointed out that it would have to increase as the square of the velocity, in order that the deflection should be as great at high as at low velocities.

Comparing the free molecules to cannon-balls, the magnetic pull to the earth's gravitation, and the electrical excitation of the negative pole to the explosion of the powder in the gun, the trajectory will be flat when no gravitation acts, and curved when under the influence of gravitation. It is also much curved when the ball passes through a dense resisting medium; it is less curved when the resisting medium gets rarer; and, as already shown, intensifying the induction spark, equivalent to increasing the charge of powder, gives greater initial velocity, and therefore flattens the trajectory. The parallelism is still closer if we compare the evolution of light seen when the shot strikes the target, with the phosphorescence on the glass screen from molecular impacts.

Focus of Heat of Molecular Impact.—The author finally describes an apparatus in which he shows that great heat is evolved when the concentrated focus of rays from a nearly hemispherical aluminium cup is deflected sideways, to the walls of the glass tube, by a magnet. By using a somewhat larger hemisphere, and allowing the negative focus to fall on a strip of platinum-foil, the heat rises to the melting-point of platinum.

An Ultra-gaseous state of Matter.—The paper concludes with some theoretical speculations on the state in which the matter exists in these highly-exhausted vessels. The modern idea of the gaseous state is based upon the supposition that a given space contains millions and millions of molecules in rapid movement in all directions, each having millions of encounters in a second. In such a case, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the vessel, and the properties which constitute the ordinary gaseous state of matter, which depend upon constant collisions, are observed. But by great rarefaction the free path is made so long that the hits in a given time may be disregarded in comparison with the misses, in which case the average molecule is allowed to obey its own motions or laws without interference; and if the mean free path is comparable to the dimensions of the vessel, the properties which constitute gaseity are reduced to a minimum, and the matter becomes

exalted to an ultra-gaseous state, in which the very decided but hitherto masked properties now under investigation come into play.

Rays of Molecular Light.—In speaking of a ray of molecular light the author has been guided more by a desire for conciseness of expression than by a wish to advance a novel theory. But he believes that the comparison, under these special circumstances, is strictly correct, and that he is as well entitled to speak of a ray of molecular or emissive light when its presence is detected only by the light evolved when it falls on a suitable screen, as he is to speak of a sunbeam in a darkened room as a ray of vibratory or ordinary light when its presence is to be seen only by interposing an opaque body in its path. In each case the invisible line of force is spoken of as a ray of light; and if custom has sanctioned this as applied to the undulatory theory, it cannot be wrong to apply the expression to the emissive light. The term emissive light, must, however, be restricted to the rays between the negative pole and the luminous screen; the light by which the eye then sees the screen is, of course, undulatory.

The phenomena in these exhausted tubes reveal to physical science a new world—a world where matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line—but where we can never enter, and in which we must be content to observe and experiment from the outside.

ART. XXVII.—*On the Chemical Composition of Triphylite*; by SAMUEL L. PENFIELD, Ph.B., Assistant in the Sheffield Laboratory.—*Contributions from the Sheffield Laboratory of Yale College*, No. LIII.

IN June, 1877, I published* an analysis of triphylite from Grafton, New Hampshire, and showed that the composition of that variety of the species conformed to the general formula $\overset{\text{II}}{R}_3P_2O_8+\overset{\text{I}}{R}_3PO_4$. I am now able to add analyses of the same mineral from Norwich, Massachusetts, and from Bodenmais, Bavaria, and also of the allied manganese-lithium phosphate, lithiophilite, from Branchville, Conn.; the results of these analyses remove all doubt in regard to the true formula belonging to this group.

The specimen from Norwich, Massachusetts, I received from Professor Brush. He had previously identified it as† forming the nucleus of a large crystal of the well known pseudomorphous black phosphate of iron, manganese and lithium, which

* This Journal, III, xiii, 426, June, 1877. † Ibid., II, xxxiv, 402, Nov. 1862.

urs at that locality associated with spodumene. This un-
ɜred triphylite is very rare, but the specimen, a portion of
ich was used for analysis, was bright and lustrous, with the
tinct cleavages, and all the physical characters of the original
ıeral. The following analyses give additional proof of its
ng quite free from alteration.

1.) Triphylite from Norwich, Mass.; color greyish green,
cific gravity =3·534.

	I.	II.	Mean.		Atomic relation.	
'₅	44·72	44·80	44·76	P		·630
	26·40	26·40	26·40	Fe	·366	
)	17·87	17·80	17·84	Mn	·251	=·633
	·16	·33	·24	Ca	·004	
)	·49	·45	·47	Mg	·012	
)	9·37	9·34	9·36	Li	·622	=·632
O	·32	·38	·35	Na	·010	
)	·53	·30	·42			
	——	——	——	Li_2	·311	=·316
	99·86	99·80	99·84	Na_2	·005	

Րhe analyses of the Bavarian triphylite which have been
ɔlished do not agree very satisfactorily, and have left some
ıbt in regard to the true composition of the mineral. With
iew to settling this point I have also analyzed an authentic
cimen from Bodenmais, Bavaria. This was furnished to me
Professor Brush; he had received it from Dr. Hugo Müller,
o had himself collected it at the locality. It was quite pure,
l entirely free from any traces of alteration. The results of
analysis are given below; it will be seen that it has afforded
exceptionally large percentage of lithia.

2.) Triphylite from Bodenmais; color light blue, specific
vity =3·549.

	I.	II.	Mean.		Atomic relation.	
₅	43·16	43·19	43·18	P		·608
	36·23	36·20	36·21	Fe	·503	
)	8·95	8·96	8·96	Mn	·126	=·652
	·08	·12	·10	Ca	·002	
)	·84	·83	·83	Mg	·021	
)	8·14	8·15	8·15	Li	·544	=·552
O	·31	·22	·26	Na	·008	
)	·92	·82	·87			
gue	·82	·84	·83	Li_2	·272	=·276
	——	——	——	Na_2	·004	
	99·45	99·33	99·39			

'hese three localities, Bodenmais, Norwich and Grafton are,
h that in Finland, the only ones at which the mineral triphy-
has been found. In connection with these it is interesting
ıote the mineral lithiophilite from Branchville, Connecticut,
ɜntly described by Messrs. Brush and Dana* and shown by
m to be analogous to triphylite in composition. This min-
was first analyzed by Mr. H. L. Wells of the Sheffield

* This Journal, III, xvi, 119, August, 1878.

Laboratory. I have made an analysis of it, but of another and slightly different variety, obtained by Messrs. Brush and Dana since the publication of their paper and from an independent, though closely contiguous deposit. The material was particularly fresh and free from alteration.

The results of the analysis are as follows:

(3.) Lithiophilite from Branchville, Conn.; color light clove brown; specific gravity =3·482.

	I.	II.	Mean.		Atomic relation.	
P_2O_5	45·22	45·22	45·22	P	·636	
FeO	13·10	12·92	13·01	Fe	·180	=·631
MnO	31·93	32·12	32·02	Mn	·451	
Li_2O	9·26	----	9·26	Li	·618	=·628
Na_2O	·28	·30	·29	Na	·010	
H_2O	·17	----	·17			
Gangue	·31	·28	·29	Li_2	·309	=·314
				Na_2	·005	
			100·26			

In the following table the atomic ratio for

$$P : \overset{II}{R}(=Fe, Mn, Ca, Mg) : \overset{I}{R}(=Li, Na)$$

is given for each of the three above analyses, and also for the Grafton mineral as analyzed by me (l. c.) and for the lithiophilite analyzed by Mr. H. L. Wells (l. c.).

	P	:	$\overset{II}{R}$	:	$\overset{I}{R}$						
Triphylite, Bodenmais,	·608	:	·652	:	·552	= 1	:	1·07	:	0·91
" Norwich, Mass.,	·630	:	·633	:	·632	= 1	:	1·00	:	1·00
" Grafton, N. H.,	·620	:	·651	:	·598	= 1	:	1·05	:	0·97
Lithiophilite, Branchville, Penfield,	·636	:	·631	:	·628	= 1	:	0·99	:	0·98
" " Wells,	·628	:	·632	:	·580	= 1	:	1·00	:	0·93

All of these approach very closely to ratio 1 : 1 : 1, required by the general formula

$$\overset{II}{R}_3P_2O_8 + \overset{I}{R}_3PO_4 \quad \text{or} \quad \overset{I}{R}\overset{II}{R}PO_4.$$

The Bavarian mineral deviates most widely from this, and a similar though less pronounced deviation is seen in that found at Grafton. In all the five cases, however, it will be observed that the required ratio of 1:1·5 for $P:\overset{II}{R}+\overset{I}{R}_2$ is very nearly given, as is seen in the following table:

	P		$\overset{II}{R}+\overset{I}{R}_2$
Triphylite, Bodenmais,	1	:	1·52
" Norwich,	1	:	1·50
" Grafton,	1	:	1·53
Lithiophilite, Branchville, Penfield,	1	:	1·48
" " Wells,	1	:	1·47

In order to bring out the relations of the different varieties of triphylite to each other in respect to the amounts of iron and manganese contained in them, and also of these in turn to the allied species lithiophilite, the five analyses from which the above ratios were obtained are given together in the following table:

	Triphylite.			Lithiophilite.	
	(1.) Bodenmais.	(2.) Norwich.	(3.) Grafton.	(4.) Branchville (Penfield).	(5.) Branchville (Wells).
P_2O_5	43·18	44·76	44·03	45·22	44·67
FeO	36·21	26·40	26·23	13·01	4·02
MnO	8·96	17·84	18·21	32·02	40·86
CaO	·10	·24	·94	----	----
MgO	·83	·47	·59	----	----
Li_2O	8·15	9·36	8·79	9·26	8·63
K_2O	----	----	·32	----	----
Na_2O	·26	·35	·12	·29	·14
H_2O	·87	·42	1·47	·17	·82
Gangue	·83	----	----	·29	·64
	99·39	99·84	100·70	100·20	99·78

This series of analyses shows in a very striking way the transitions from triphylite, the phosphate of *iron* and lithium, to lithiophilite, the phosphate of *manganese* and lithium; to the first belongs the formula $LiFePO_4$ and to the second $LiMnPO_4$.

In closing this paper I wish to acknowledge my indebtedness to Professor George J. Brush, who has most liberally furnished me with the material needed for my examination.

Sheffield Laboratory, Dec. 16, 1878.

Art. XXVIII.—*Notes on the Mesozoic Strata of Virginia*; by Wm. M. Fontaine.

[Concluded from page 157.]

Petersburg Belt.—This exhibits many of the peculiar features seen in the Fredericksburg Belt, but on a more exaggerated scale. We do not however recognize more than one series. The strata are well exposed at Richmond in the lowest points reached by the erosion of the streams. They occur here with the Eocene and Miocene in place above them. They form the lowest visible beds in the river bank all the way down to Farrar's Island, and a short distance eastward of it. They also occur in a similar position in the banks of the Appomatox up to Petersburg, being in the vicinity of the rivers covered by only the lowest of the Eocene strata, the rest of the Tertiary having been removed. The canal cut by General Butler in the late war, through the narrow neck of Farrar's Island at Dutch Gap, in order to avoid the bend of the river, gives a good exposure. The description I shall give of the strata applies more particularly to the beds exposed at this last named locality, though it is applicable with some modifications throughout the belt. The beds incline gently eastward, and disappear under the Tertiary. It is not known how far they pass in this direction, but from their great comparative development where they disappear, they no doubt penetrate

far under the Tertiary. The lithology and stratigraphy present many remarkable features, only a few of which can be noticed. The thickness of the strata and coarseness of the component matters, strange to say, is greatest at the farthest point to the east at which they show themselves, viz: near Dutch Gap, although the source of the material is to the west. Not more than fifty or sixty feet of strata appear in the banks of the stream here, but from the manner in which the bluffs descend beneath the water, and the depth of the latter, the total thickness near Dutch Gap cannot be less than one hundred and fifty feet, while near Richmond it is not more than fifty or sixty feet. The variableness of the material, and the complexity of the rapidly shifting planes of false-bedding are so great, that no two sections taken a few feet apart will be similar; indeed the entire mass has the character of a "Kame."

The greater portion and the finer matter of the beds is a sort of incoherent grit, composed of grains of quartz, particles of feldspar in all stages of decomposition, and scales of mica, all mingled together without sorting and devoid of lamination, forming a mass without bedding, but penetrated by numerous and intricate false-bedding planes. This material which is plainly derived from the granitic and gneissic rocks to the west, is filled with small stones which are scattered confusedly throughout its mass. These are usually composed of quartz. While this is the more common material, we often find that locally, most of the material is the previously mentioned white, non-plastic earth, mingled with great quantities of small Potsdam stones, the whole being formed of the debris of Potsdam strata. Throughout the series, beds and pockets of large stones occur of very variable extent and thickness. These are much more abundant towards the top. They seem to be formed by the local removal of the normal grit, and the filling of the excavations with the stones. Thus we find that a mass of large stones, composing nearly all of the visible bank of the stream, will pass abruptly into the ordinary pebbly grit, or even fine sandy matter. Such pockets of stones are composed almost entirely of Potsdam quartzite and sandstones, well rounded and smoothed. The stones are more commonly under eight to ten inches, but they occur a foot or more in diameter. They are usually packed in a finer material composed of Potsdam debris. While these masses of stones are especially abundant in the highest portions of the series, they are not confined to this. Thus the lowest stratum that I saw exposed, was composed in one locality of rounded Potsdam stones, six, eight, ten and even twelve inches in diameter, packed as closely as possible together, and looking much like a section of the cobble-paved streets of Richmond.

Toward the top of the series, we find very commonly short layers, and nests of clay enveloped in the grit, but so sharply distinct from it that the clay seems to have been laid down on depressions in the surface of the grit during pauses in the deposition of this material. The distinctness is so great that at the line of junction of the two, the grains of the grit may be picked out separately from the clay. This clay sometimes, however, is interstratified for some distance with the sandy matter, the layers of sandy grit and clay alternating but not passing into each other. The clay is most commonly bluish or grayish in color, less commonly, pale reddish or liver-colored. It is very fine grained, highly plastic and tenacious, and thus contrasts strongly with the matter in which it is imbedded. The layers are rarely over a foot thick, and sometimes occur at short intervals apart, separated by the pebbly grit. They then often show the curious features of inclining at various angles toward each other, and of being cut off abruptly by the coarse matter. A seam of clay will thus sometimes abut against a nest of stones. In one place I saw three such short layers diverging from one extremity (where, however, they were not united) like the fingers of a hand, and ending abruptly in the normal pebbly grit. They do not usually extend horizontally more than twenty or thirty feet.

With these clay seams we often find rolled masses of similar matter, which sometimes have the diameter of four or five feet. These balls are enveloped in the grit, and commonly are attended with large Potsdam stones. The balls are plainly produced by the tearing up of the clay immediately after deposition. Sometimes a portion of a clay bed will be cut away by the eroding force, and rolled some distance and then covered by the floods of sandy matter carried forward by the agent which produced the erosion. These clays must have been brought from a very different source from that which yielded the coarse matter, and they seem to have been laid down on the irregular and shifting surface of the grit in pauses of the action of the force which produced this latter, hence the irregular inclination and local development of the clays. A renewal of the action of the powerful force which was involved in the transport of the coarser matters, would cut away and bury the clays. I do not find in place, any deposit which by its erosion could have yielded these clays. Their composition and character is just that of the thoroughly decomposed and slowly accumulated matter from granite and gneiss. I am strongly inclined to the opinion that they represent marshes within the Azoic area, which were swept away in the general and extensive erosion of its surface which took place at this time. This clay is of special importance as it contains the

plants to be mentioned farther on. Besides well-preserved plants, it contains much lignite and comminuted vegetable matter which gives it often a dark color. The plants are all drifted apparently from some distance, and but a small number are well enough preserved to be determined. The texture of the clay is so close that sometimes the entire substance of the plant is preserved.

The summit of the grit is sometimes partly laminated and contains occasionally a layer of clay, as if a pause in the sedimentation had taken place for a short time. On this, or on the summit of the grit, there occurs very generally, but not always, a very remarkable bed of stones packed in grit like that of the mass on which it rests. This latter is more or less eroded and trenched. This bed of stones is, I think, the representative of the surface stones mentioned above as occurring in the Fredericksburg Belt. It represents a force which swept over the Azoic on the west, as well as over the Mesozoic here, and in the Richmond Belt. It seems to have been the closing deposit of the Mesozoic series in these border belts for it is followed by the Eocene strata.

These stones form a most heterogeneous mass, a true drift deposit. The mass is of varying thickness, usually six to ten feet. Sometimes, however, it thickens up to fifteen or more feet and thins down to three or four, or disappears. The material is a mixture of gravel, large rounded stones, and more or less angular and large masses. The rounded stones are mostly Potsdam, usually four to six inches in diameter or under, but quite often one and two feet. The smaller stones are well rounded, the larger are sub-angular but still quite smooth. They often show Scolithus markings. Mingled with these, usually occurring at the top of the bed, we find the large blocks which are of Azoic rocks, and include varieties found at various points to the west as far as the Blue Ridge. It is noteworthy that this is the only horizon in the Mesozoic here, which shows any coarse matter but quartz, which would be furnished by the Azoic. The most numerous of the masses and the largest, are furnished by the granites and gneisses west of Richmond. Blocks of these, three to four feet in diameter are common, but sometimes they are ten and twelve feet. These are usually more or less abraded. Gneiss and mica schist from farther west occur in large slabs, sometimes showing but little wear. Some vein quartz from the Azoic, and fragments of the sandstones of the Richmond Coal field are seen, but not commonly. Masses of the peculiar chloritic and other schists of the Blue Ridge far to the west, are not rare. These often attain the dimensions of three or four feet, and are commonly but little abraded. None of these stones or those of the Fredericksburg

Belt, show glacial striæ, but some of them show a mode of wear and polish highly suggestive of ice action. Indeed it is not probable that these fragments would show striations even if they had been imbedded in ice moving over the land, for the surface was no doubt too deeply decayed, and in too incoherent a condition to produce scratches.

Besides the Potsdam, we find other material which has been brought from west of the Blue Ridge. Slabs of the characteristic fossiliferous layers of the Chemung occur, but rarely however. They contain impressions of the stems of Chemung Crinoids.

Fossil Plants.—Though the clays are full of vegetable matter, it is only locally, and in very restricted layers, that we find determinable plants. These are very interesting and sometimes beautifully preserved. They consist of Conifers, Ferns and Cycads. The Conifers sometimes retain their cones. They belong to several species, among which we may mention a plant very close to, if not identical with, *Widdringtonites Haidingeri* Etting., a Wealden species. Another is very near to or identical with, *Araucarites curvifolius* Etting., also a Wealden plant. The ferns and a Jeanpaulia, have a decided Wealden facies. But the most abundant and characteristic plant of the beds is a fossil identical with that fine Cycad, *Pterophyllum* (*Dionites* of Schimper) *Buchianum* Etting., which is a species of the Wealden of Germany. This exists in immense numbers, and shows compound leaves two feet long. I observed, imbedded in the grit composing the bank of the canal at Dutch Gap, a coniferous tree which in the part projecting from the earth is eighteen inches in diameter. Forty feet are said to have been cut off from it in opening and widening the canal. It is merely browned and does not yet seem to have reached the stage of true lignite. The wood seems to be like that of *Pinus strobus*, and shows the annual rings distinctly. It may be worked with tools, not having wholly lost its coherence. The grit contains only lignitic and silicified wood. Taken as a whole, the plants are decidedly Wealden. I did not see a single species similar to those of the Richmond coal field, though several seem identical with Fredericksburg species.

Surface deposits of the Azoic.—If we ascend from the river to the top of the hills near Dutch Gap, we find ourselves on an undulating plain, composed of Tertiary sands and clays, and possibly later beds. We observe no drift matter on this surface. If however we proceed westward, we find the Tertiary accompanying us until we approach the Azoic border, and still without surface drift. But in the vicinity of the Azoic, where the Mesozoic crops out from under the Tertiary, we find the Potsdam stones, Azoic erratics, fragments of Mesozoic sandstones,

etc., quite abundant, lying scattered over the surface. Passing still farther west, we find the same material with the fragments of the Richmond coal rocks becoming more abundant, and when we pass west of this field these coal rocks disappear, but we still have the other material. The Potsdam stones however do not pass westward over the whole Azoic area. They become confined to a belt along the James, in the upper course of that river. I do not know what is their disposition on the Upper Appomatox, as I have not examined the country in that quarter. It is plain that this coarse drift is the product of the same force which formed the uppermost bed of the Mesozoic at Dutch Gap.

The belt of Azoic, with the included Richmond belt of the Mesozoic, which contains on its surface Potsdam stones mingled with the fragments of Azoic rocks, is about twenty-five miles wide south of the James. It narrows to ten or twelve miles near the northern end of the Petersburg Belt, on the North Anna. West of this the Azoic drift masses are still found on the surface, up to the Catoctin Mountains but no Potsdam stones. It is noteworthy that this drift is usually almost entirely quartz, often in blocks two and three feet thick, representing the quartz of the veins so common in some of the Azoic strata. The reason why we do not find more of the crystalline schists is, because the deep decay which had affected these rocks at the time of their erosion, presented to the eroding agent only friable grits and clays with the quartz veins in them standing in their original position.

In the more westerly localities where the Potsdam is no longer found generally over the surface, I noticed that the bands of these Potsdam stones along the James do not follow the present windings of the stream but pass directly across the bends. They occur 150 to 200 feet above the river, and lie on the general level of the adjoining country.

The drift matter in the vicinity of the border belts, within the limits containing the Potsdam stones, covers the surface of the Azoic with a pretty continuous layer. But portions of it seem to be thicker than the general mass, corresponding to belts which were more deeply scored by the eroding agent. These have a direction a little north of west and south of east, showing the direction from which the eroding agent came. Sometimes, however, modern surface or stream erosion has so arranged these drift matters, as to cause them to appear to come from some other quarter than the west, which is their true source. This has misled Mr. R. P. Stevens, who visited the Richmond Coal-field some years ago, and came to the conclusion that the mode of transport was the movement of a glacier from the northward, in the Glacial Period. He states his views in a letter published in this Journal, Nov., 1873.

Professor Wm. B. Rogers, in an article entitled the "Gravel and Cobblestone Deposits of Virginia, and the Middle States," published in the Proc. Boston Soc. Nat. Hist., 1875, gives some account of the drift matter seen at Richmond, Alexandria, Washington, etc. Not having traced this material away from the vicinity of the James and Potomac, and finding it resting on the Tertiary, he was disposed to attribute its transport to the work of these streams in the Glacial Period, aided by the action of ice. While I think that most of this matter is of older date, yet I am convinced that considerable additions to that lying at the lower levels were made in the Glacial Period. I find drift matter on the Potomac, the James, and the Roanoke, which I think was brought during the Glacial Period, but this does not rise more than about sixty feet above the present water level. There is a great deal of drift along all these streams at that height, especially on the Roanoke.

The last of the surface deposits on the Azoic which are of importance are certain clays which are the most widely diffused of all. Thus we find them over the surface of the Azoic everywhere, to the west of the Petersburg Belt as far as the Catoctin and the Blue Ridge. They are not continuous but rather form irregular sheets. I cannot assert that these clays occur to the west of the northern end of the Fredericksburg belt, or that the Azoic drift in that quarter extends far westward of the eastern edge of the Azoic, as I have not made any extended examination there, but so far as I have examined, the condition of the surface is much as it is west of the Petersburg Belt. These clays are the only transported matter that I observed in the southern part of the State, in Pittsylvania County. Here they occur in the same way as in the northern district, now being described.

These clays are nearly always blood-red in color and rich in lime. They form a highly fertile subsoil, no matter on what sort of rock they may rest. They lie on all kinds of rocks, and are entirely independent of them. We find them on the gray grits of the Mesozoic; on the granite, with its surface decomposed to a white kaolinic grit, which shows the utmost possible contrast with the clays; or on mica-schists, etc. There is no rock east of the Blue Ridge rich enough in lime to yield these clays, except the epidotic schists, and hornblendic rocks which abound so between the Blue Ridge and the Catoctin. The clays contain decomposed fragments which resemble these strata, and when we can follow them, as we do up to these schists, we may conclude without hesitation that such is their origin. Hence they must have been transported in many cases, fifty or sixty miles. This however is not strange when we see that the Potsdam and other rocks from west of the Blue Ridge, must have

often traveled 100 miles and more measured in an air-line, and much farther, if the course of the rivers crossing the Blue Ridge be followed. Professor Rogers in the old survey of the State, noticed these clays and expressed the belief that they must have been transported from the west.

They lie at the same horizon occupying the highest levels, and mark the plane to which the country was cut down at the close of the Jurassic. We accordingly find them in the hill-tops and over the intervals between the rivers. But owing to this high level, they are often removed by erosion. These clays are usually accompanied by the coarse drift. When this is present they either lie on the drift or contain it within their deposits. The latter position of the drift stones however is rare. The clays pass up to the edge of the Tertiary but not over on it. They are conspicuous on the granite near Richmond, which when the clay covering is removed, presents rounded and smoothed surfaces. These red clays generally are covered by a greater or less depth of gray soil, usually not over a few feet.

General remarks and Conclusions.—It is a noteworthy fact that the belts of Mesozoic which yield coal, contain it mainly at their southern or higher extremities. This is true of the Richmond Belt, of the Prince Edward Belt, and of the Pittsylvania Belt, which terminates in the Dan River coal field in North Carolina. This was perhaps caused by the fact that the southern ends of the Mesozoic areas, being higher, were better fitted for the formation of marshes.

I think that many of the features described in the preceding pages can best be explained by supposing that, in Triassic and Jurassic times, the Appalachian Mountain region was receiving supplies of snow too great to be removed by melting. Consequently the excess must have been discharged by glaciers. These must have advanced and receded more than once in the earlier periods, but did not penetrate to the sea. Toward the close of the Jurassic they advanced in such force that they reached the sea. In the intervening time, while the ice was gathering force, ice rafts, charged with stones and earth, floated down the streams which issued from the foot of the ice. To the frequent pushing forward, and consequent abrasion of the matter accumulated at the foot of the ice, and in the upper course of the rivers, we must attribute much of the rounded and polished condition of the Potsdam stones now found so far to the east of their original position. This ice may have made its final advance over the whole of the portion of the Atlantic slope in which the features above described are found, or it may have issued from the Blue Ridge, mainly along the line of the Potomac and James, and then in its farther advance to

the east have spread laterally, so as near the border of the Azoic, to have coalesced into one sheet. The facts observed rather favor the latter method of advance. From this supposition it would follow that the Mesozoic areas were fed by the cold waters issuing from the ice and snow on the mountains. This may account for the paucity of animal life, especially Molluscan life, that they show. The only marine waters with which they could communicate contained forms that could not live in the cold inland waters.

It is probable that the courses of the present principal streams were marked out by this ice action, and hence come their direct course and independence of the character of the rocks over which they flow. There is no difficulty in explaining the growth of the plants, now found fossil, at a time when the Appalachian Mountain belt was covered with snow. All that was needed was a raising of the present winter temperature in the lowlands, for we shall show that for the formation of glaciers on the heights the climate need not have been colder than at present. Owing to the non-existence of the Rocky Mountains, the cold western and northwestern winter winds of the present time would not by reflection from that chain then reach the eastern slopes. At the same time the greater extension of the Gulf waters northward would cause southerly winds to sweep over these slopes. These winds passing over the cold waters of the lakes and great rivers would form abundant fogs. Thus a mild, equable, and moist climate would be produced in the lowlands, even if the earth had its present amount of cold, causing the growth of ferns, cycads, etc., and covering the hills with the immense growth of coniferous trees which we know must have existed. This condition of things would also have been eminently favorable for the production of coal. This was only brought to a close in the final advance of the ice at the end of the Jurassic Period, when all the abundant forms of plants of that period were extinguished to appear no more. No other cause seems adequate to explain the total extinction of the Jurassic flora, and the complete change which we find in the succeeding Cretaceous flora.

But while the plants were growing in the lowland and around the lakes, a very different condition of things prevailed in the high Appalachians. The stratigraphy of the formations composing this belt, and the amount of erosion which, as we know, took place, make it clear that in the early Mesozoic times much of this region must have stood above the snow line, and a still larger portion near it. If we recall the physical features of the North American continent which existed at that time, we shall see that even with our present climate then prevailing, the conditions would have been eminently favorable for the

formation of glaciers. Along with a sufficient degree of cold we must have abundance of moisture to produce glaciers. This would be supplied by the western and southwestern winds. The latter would sweep unchecked from the Pacific over vast bodies of warm waters in the interior, and meeting the lofty mountain belt of the Appalachians, would give unlimited supplies of snow. The configuration of this elevated district, with its broad slopes, and long valleys inclining in one direction, would be eminently favorable for the collection of snow and its discharge in the form of glaciers. Indeed this region must at that time have formed a perpetual storm center. We are not without evidence, however, that a period of cold greater than that now existing, prevailed toward the close of the Jurassic, and in this we find the explanation of the advance of the ice so far to the east at that time.

Mr. Judd, in his excellent paper on the Secondary Rocks of Scotland, published in the Quar. Jour. Geol. Soc., vol. xxix, gives a description of certain very remarkable beds of stones, which under the name of the "Brecciated Beds of Ord," form the uppermost beds of the Upper Oolite of the east coast of Scotland. These beds are composed of huge masses of stones brought from a distance, and packed in fine argillaceous matter. The conditions are such that it is impossible for water alone to have transported the material. Hence some of the English geologists attribute this formation to ice action. The beds of stone are interstratified with shale beds, containing a beautiful Oolitic flora. Many of the features seen here resemble those of the beds at Dutch Gap. The question suggests itself whether at the close of the Jurassic an ice sheet did not cover the northern part of Scotland, extending east and west. If so, we may have in the melting of this ice, the source of supply of those waters which formed the fresh water Wealden deposits of England and northwestern Germany. It is well known that it is a puzzle to determine whence the great rivers which fed these lakes could have derived their abundant waters.

Another question may be asked. Is it not possible that some of the drift of our northern States, which is attributed entirely to the action of forces in the Glacial Period, may be much older? It is well known that none of the Mesozoic areas of the Atlantic slope seem to have had perfect communication with the sea. May not this be due, at least in the latest formed of them, to the great quantity of drift matter accumulated seaward, and not in all cases to an elevation of the coast?

The question whether drift deposits, similar to those of Virginia, may or may not be found in the States lying around the southern prolongation of the Appalachian belt, is worthy of the attention of geologists. Sir Charles Lyell, in his account of his second journey to the United States, mentions some

significant features, which in Georgia and Alabama, attracted his attention on the line of meeting of the Tertiary and Azoic. He mentions seeing erratic masses of various sizes and character, which rest on the Azoic, pass up to the Tertiary, but do not pass over on the latter. He noticed this drift as resembling the northern Glacial Drift. If this is of Upper Jurassic age, then it ought not to pass over the Tertiary but under it. Again, he mentions seeing in Alabama, at the base of the Cretaceous, "dense masses of shingle perfectly loose and unconsolidated, derived from the waste of Paleozoic strata, a mass in no way except by its position, distinguishable from ordinary alluvium."

Tuomey mentions at Aiken, in South Carolina, beds of gravel and sand, without fossils, and lying at or under the base of the Cretaceous. Lieutenant Vogdes thinks that these may be Wealden.

Morgantown, West Virginia, Nov. 4, 1878.

ART. XXIX.—*Notice of recent Additions to the Marine Fauna of the eastern coast of North America, No. 3*; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XL.*

AMONG the many interesting additions recently made to the American marine fauna, are two handsome undescribed species of "sea-feathers" (Pennatulaceæ) and three fine new species of hydroids, belonging to the family Plumularidæ, of which only three species have previously been known to inhabit our northern coast. Those now added appear to belong to the genus *Cladocarpus*, recently established by Allman, for several deep-water forms, from the coasts of Europe and the Gulf of Mexico. Two very interesting Cephalopods have also been recently added to our fauna.

ANTHOZOA.

Virgularia grandiflora, sp. nov.

A large, stout species, with very large polyps, which are only slightly united, close to their bases. Rachis stout, ventral side convex, and with a wide naked space; below the polypiferous portion there is a marked fusiform swelling, with longitudinal wrinkles; the end is bulbous and perforated; at the distal end the naked rachis extends about 8^{mm} beyond the last polyp-cells, and tapers to a blunt tip. Axis rather stout, rounded, yellowish white. The polyp-cells are large, and arranged in very oblique, rather irregular rows, seldom containing more than six or eight, and separate so nearly to the

* Nos. XXXVII and XXXVIII were, by an error, doubly employed in this series. This is, in reality, the forty-second article.

base that they form only very rudimentary alæ, while in some states of contraction they appear entirely disunited. The rows are rather distant on the same side, and on opposite sides alternate irregularly, and the dorsal members of adjacent rows intermingle or overlap, while the polyps in the middle region usually stand alternately farther forward and farther back in the same row, while the most ventral one is usually placed farther toward the ventral side in each alternate row; the polyp-cells are stout, cylindrical, soft, slightly eight-ribbed, considerably contractile. Tentacles, very long, tapering to a long slender tip, with very numerous, slender lateral lobes. Most of the polyps are well expanded; a very few have the tentacles nearly retracted. Zoöids are numerous, small, but very distinct, covering the lateral intervals between the rows of polyps and usually extending into the intervals between their bases, while along the ventral side the lateral patches are usually connected by a belt of zoöids running outside of the most ventral polyp-cells, but those of the latter that stand out more than usual, usually interrupt these belts. No calcareous spicula were found in the polyps or cœnenchyma. Color of the rachis and polyp-cells brownish yellow, in alcohol; tentacles dark brownish red.

Length, 350^{mm}; of naked peduncle, 60^{mm}; diameter of bulb of latter, 10^{mm}; of narrow portion, 5^{mm}; of rachis, 5 to 8^{mm}; of axis, $1·5^{mm}$; diameter of largest polyp-cells, 3^{mm}; their length, 5^{mm}; length of tentacles, 6 to 7^{mm} or more.

Taken on a trawl line, in 220 to 260 fathoms, lat. 42° 46′; long. 63° 45′, by the crew of the schooner "Laura Nelson," Capt. R. N. Morrison. This is a very handsome and remarkable species, of which only a single specimen has been obtained. It differs widely from the previously described species of *Virgularia*, and approaches Kölliker's genus *Halipteris*, in appearance, but differs in the character of the polyp-cells and in the absence of spicula.

Funiculina armata, sp. nov.

A long, slender species, with large, rigid, urceolate, spiculose polyp-cells, armed at the aperture with eight, sharp, divergent spiculose points. Axis and rachis quadrangular, slender, the sides of the axis concave. The polyp-cells are entirely separate and arranged in numerous irregular transverse clusters of two to four, smaller and larger intermingled: they are so stiffened by spicula as to be scarcely flexible, and retain well their form: they are elongated, swelling out gradually from near the base and tapering again, above the middle, to near the summit, which suddenly expands to the edge, from whence eight, long, acute, rigid, white points diverge; tentacles spiculose, but wholly retractile within the cells. Among the ori-

dary cells are small clusters of much smaller zoöids, which are white, prominent, larger at summit than at base, and possess eight rudimentary tentacles. The polyp-cells are filled with long, slender, smooth, triquetral, or three-winged, prismatic spicula, arranged in longitudinal bands and irregular transverse clusters, while a convergent cluster forms each of the eight points at the summit; similar, but smaller, spicula occur in the main stem of the tentacles. The ova are large and situated both in the polyp-cells and in the cavity below their bases, where a considerable cluster can be seen when, as often happens, the cells are broken off. Rachis yellowish white below, light orange-brown above; polyp-cells darker brown, with white spicula; tentacles dark brownish red.

Height, 600^{mm}; diameter of rachis near base, $1{\cdot}5^{mm}$; in middle, about 1^{mm} to $1{\cdot}5^{mm}$; length of larger polyp-cells, about 6^{mm}; diameter, 1·5 to $1{\cdot}75^{mm}$.

Taken on a trawl-line in 300 to 400 fathoms, about forty miles southwest from the N.W. Light of Sable Island, N. S., by George K. Allen, schooner "M. H. Perkins."

Ptilella borealis Gray = *Pennatula borealis* Sars = *Pennatula grandis* Ehr. (*non* Pallas) = *Ptilella grandis* Kor. & Dan.

Several additional specimens of this species have been received from off Nova Scotia.

In the Fauna Litt. Norvegiæ, vol. iii, p. 82, 1877, Koren and Danielssen have given an elaborate description of this species, with figures. They have shown good reasons, apparently, for adopting Gray's genus, *Ptilella*, for this form, but inasmuch as Ehrenberg's name (*P. grandis*) had been preoccupied, it ought not to be used for this species.

CEPHALOPODA.

Histioteuthis Collinsii, sp. nov.

A very large and handsome species, with a broad thin web, extending between and nearly to the ends of the six upper arms. Tentacular arms about two feet long and slender, expanding near the end into a broad, long-oval, sucker-bearing portion "or club," which is bordered by a membrane, widest on the outer edge; it ends in a tapering tip, on the back of which there is a thin crest-like membrane or keel, enlarging backward to the end, where it forms a rounded lobe. The most expanded portion of the "club" bears five rows of suckers, with finely serrate rings; two rows contain much the largest suckers, four or five in each, the more central of the two rows containing four suckers larger than the rest; outside of these are two rows of medium-sized suckers, and along the inner edge of

the club there is one partial row of similar ones, while along the inner edge of the proximal portion of the club there is a row of smooth-edged suckers, alternating with tubercles that fit into corresponding suckers on the other arm; a row of similar but smaller suckers extends for about six inches along the inner median line of the arm, alternating, two by two, or singly, with tubercles, and gradually becoming more distant. The tip of the arm, beyond the expanded club, bears minute serrate suckers, at first in six rows, decreasing to two at the end. Sessile arms stout, three-cornered, tapering to slender tips, each bearing two rows of globular suckers, having a small, oblique opening and few blunt teeth.

All the arms on the left side are an inch or more longer than the corresponding right ones. The dorsal and ventral arms, of the same side, are about equal, and decidedly shorter than the two lateral pairs, which differ but little in length. A broad, thin web, about two-thirds as broad as the length of the arms, unites the upper three pairs together, and as a narrowing border extends along their sides, nearly to the tips. The lower lateral arms have a thin, crest-like membrane on their outer, median surface, commencing at the basal fourth and extending nearly to the tips. The ventral arms are united together, near the base, by a web, which also unites to the main web, in the median plane. A narrow web, arising from the outer angles of the arms, also unites all the arms together for a short distance above their bases. Eyes mutilated, their lids form a large, simple, rounded opening. Beak with very sharp black tips; a broad membrane, rising into six prominent angles, surrounds the mouth. The outer surface of the head and arms is covered with large, very slightly raised warts or tubercles, which are dark blue with a whitish center; a circle of them surrounds the eye lids. Color, between the warts, purplish brown, with dark brown spots, and reddish specks; web and inner surface of arms uniform dark reddish brown; suckers yellowish white; tentacular arms light orange-brown.

Tentacular arms 24 and 25 inches long; diameter at base, ·5; breadth of club, ·70, without membrane; its length, 2·75; length of the slender tip, 1·25; of dorsal crest, 1·5; length of dorsal arm, of left side, 14 inches; 1st lateral, 17; 2d lateral, 17·25; of dorsal, 14·25; breadth of lateral arms, at base, ·9; thickness, ·75; diameter of eye-opening, ·9; diameter of head, at base of arms, 3·5.

Taken from the stomach of *Alepidosaurus*, lat. 42° 49′, long. 62° 57′, off Nova Scotia, by the crew of the schooner "Marion," Capt. J. W. Collins.

All parts back of the eyes are absent, the eyes are mutilated, but the specimen is otherwise in excellent preservation, even

the thin web and the colors being uninjured. With it was the terminal portion of an arm of a gigantic squid (*Architeuthis*), too much injured for specific determination. I have named the species in honor of Capt. Collins, to whom and the crew of his vessel, we are indebted for so many interesting and novel specimens.

Taonius hyperboreus Steenst. (?)

A large and handsome species of this genus has just been received, which may be this species, though in its proportions differing from Steenstrup's measurements. The eyes are very large and globular, in contact, beneath the head. The arms are very short, and part of them have lost their tips and afterwards healed. The tail is long, lanceolate, tapering to a very long, slender, acute tip. Color brownish red, with rather large rounded, dark brown spots. Length of head and body, 13·5 inches; edge of mantle to tip of tail, 12; tail, 5; its breadth, 1·8; diameter of body, 2·25; of eye, 1; length of ventral arms, 1·9; of lower lateral arms, 2·25.

Taken at the surface, in the northern edge of the Gulf Stream, W. long. 55°, by Mr. Thomas Lee, schooner "Wm. H. Oaks," Jan., 1879.

ART. XXX.—*Note on the Age of the Laramie Group or Rocky Mountain Lignitic Formation;* by H. M. BANNISTER.

IN his recently issued report on Systematic Geology, vol. i, U. S. Geological Exploration of the 40th Parallel, Mr. Clarence King discusses at length the disputed question of the age of the Rocky Mountain lignite series, to which, by agreement with Dr. Hayden, he gives the name of the Laramie group. In his argument for the exclusively Cretaceous age of these beds, it appears to me that he has generalized too freely, and I propose to notice a few omissions and points where he seems to me to be in error.

We may leave aside all the paleontological evidence of the age of these beds, the general Eocene aspect of their invertebrate fauna, which, I believe, no one has disputed, the Tertiary *facies* of the flora, which, I believe, is an issue between Professors Lesquereux and Newberry, and the Cretaceous Saurians found high up in the series, as all compatible with the theory of its transition character, and the question of its conformability remains. Mr. King asserts that it is absolutely unconformable with the overlying Vermilion Creek group, and that nowhere, save in one locality, is there any appearance of conformability between the two. I should hesitate to disagree with him, were

it not that when examining this formation with the late Mr. F. B. Meek, in the year 1872, we both thought we found evidences of conformability between these strata and the overlying Tertiary in other localities than Black Buttes, the one admitted by Mr. King. Then, in examining the reports of other geologists who have visited the region, I find that their observations in these localities, as far as stated, agreed with ours. Among these I may perhaps include Mr. King himself. He says (p. 334), "Good exposures of the Laramie group beds may be seen along the railroad, just east of Separation station, where they show the peculiar ashen gray sandstones, containing a considerable development of argillaceous beds, and a great number of coal seams, and contain plentiful plant remains, generally as leaf-impressions, and frequently also as indistinct and partially carbonized stems in the impure sandstones. In the ridge south of this station, they dip at an angle of 10° north, but flatten out to the north, so *that the line between them and the overlying Tertiaries is even more difficult to determine* than the exact division between them and the underlying Fox Hills group." (Italics mine.) Now, at this locality, Mr. Meek and I examined a thickness (estimated) of eighteen hundred feet or more of conformable beds, and in the upper portion found abundance of purely fresh-water shells, and a fragment of bone, apparently of a turtle. At the base of this series was a heavily bedded sandstone, exactly similar to that which forms the only constant horizon at Black Buttes, and the overlying strata were not dissimilar to those at the latter locality.

In the report on Descriptive Geology of the same survey, Mr. Emmons, Mr. King's assistant, when speaking of this same region, uses the following words (p. 207, vol. ii, U. S. Geol. Expl. 40th Parallel): "To the west of Rawling's Peak, as we have seen, the Cretaceous strata fall off with an ever decreasing angle of dip, assuming to the north of the railroad, between Separation and Washakie, an almost horizontal position, and are gradually succeeded by the overlying, and, in this region, conformable beds of the Vermilion Creek Tertiary." This passage sufficiently indicates that the conformability of the strata is not merely local; and that it is also not local at Black Buttes, is proven by the testimony of Professor Cope, who found it to exist for miles south of the station, while our observations were made to the north. Thus we have a conformability, as far as observed, on both sides of the Washakie Tertiary basin, according to the testimony of Mr. King's own survey.

Passing to the westward, we find Mr. King speaking as follows in regard to the Evanston coal-bearing strata which, by Mr. Meek and myself, had been regarded as of uncertain but probably of Tertiary age. "At Evanston the highest portions

of the Laramie Cretaceous are not exposed, but the sandstones near the summit of the group contain the enormous workable coal-beds of the Rocky Mountains and Wyoming Coal Companies. These coal-bearing Laramie beds dip at angles from 16° to 25°, whereas the Vermilion Creek Tertiaries are nearly horizontal over them, and carry remains of the genera *Coryphodon* and *Eohippus* and fishes." Mr. Emmons says, speaking of the same beds, that there is no doubt but that they belong to the Cretaceous and probably to the Laramie group, though, from the lack of paleontological evidence, this reference is simply conjectural. Now, so far as I can learn, not a single salt- or brackish-water fossil has been found at this locality, though land and fresh-water shells are abundant in strata immediately above the coal, the flora is said to be Tertiary, and in these same dipping beds—not in the nearly horizontal ones mentioned by Mr. King—Professor Cope found an Eocene vertebrate fauna, identifiable with that of the lower Green River epoch (Vermilion Creek Tertiary.) Moreover, if the coal is near the top of the Laramie series, which here, according to Mr. King, dips unconformably under the Tertiary, what are we to do with over twenty-four hundred feet of strata overlying it conformably and of which a section was taken by Mr. Meek and myself? As a detailed section it is of no special value, the strata vary sometimes within a very short distance, but its vertical extent is of interest in this connection. It is highly probable that it includes the horizon of the limestone bed with vertebrate remains discovered by Professor Cope, which was possibly only local; such beds sometimes run out in a few rods or yards. A comparison of the lower part of the section made at Almy, by Mr. Meek and myself (p. 540, Hayden's Annual Report for 1872) and one including the same horizons also made at Almy, which is given by Professor Lesquereux, on page 338 of the same volume, will sufficiently illustrate this fact. The sandstones, indeed, often suggested beach deposits rather than regularly deposited strata.

That these Laramie beds and the overlying Tertiaries are often unconformable may be readily admitted without invalidating the hypothesis of their transition character. They are sometimes unconformable in themselves; an apparent nonconformity was noted just below the horizon of Black Buttes, and another, many hundred feet lower down, has been made the dividing line between the Tertiary and Cretaceous by Major Powell and Dr. White. The evidence appears to me to indicate that the Laramie epoch was throughout one of stratigraphic disturbance rather than that there was only one great orographic change at its close, and that the reasonableness of the opinion of its transition character is not yet altogether disproved.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On Gelatinous Silica and on an Inorganic membrane formed of it.*—ULLIK has experimented on gelatinous silica and has prepared it in such form as to be used in dialysis. The transparent jelly which is obtained when a dilute solution of water glass is poured into hydrochloric acid, is well known. The author has succeeded in washing it absolutely free from sodium chloride and the excess of acid, and in producing pure silicic acid as a perfectly transparent jelly. In the air it dries to a transparent mass, about one-fifth in volume, breaking into fragments resembling hyalite, and pretty hard. Four decigrams of the dry mass gave when evaporated with hydrogen fluoride, a residue of only 0·0016 gram. It corresponds nearly to the formula H_2SiO_3. Suddenly ignited, it gives a brilliant sand; but heated with care, the temperature rising very gradually, up to full ignition, it retains its form and glassy transparent masses are obtained. The dried has a sp. gr. of 1·84 to 1·907, resembling opal; the ignited, of 2·322 to 2·324, which is that of tridymite. The facility with which the gelatinous silica was washed led the author to conclude that diffusion had taken place through it and hence that it possessed the properties of a membrane. To prove this definitely, the bottom was cracked out of a precipitating glass, the edges pressed down upon a piece of rubber covered with filter paper, and the mixture poured in. After solidification of the silicic acid, the whole was immersed in water, the filter paper removed, and the gelatinous mass washed by repeated renewal of the water. In this way a dialyser was made whose mouth was closed completely by a membrane of silicic acid three millimeters thick. A second one had a membrane half a millimeter thick, supported by paper. Experiment proved that no filtration took place through these membranes, but that they allowed diffusion to go on readily. For example, 50 cm. of a 20 per cent sugar solution being placed in the dialyser, it being immersed in water until the level was the same within and without, there was produced in three days a difference of level of 12 mm. with the thicker, and 20 mm. with the thinner membrane; and there had passed out into the water 14 per cent of the sugar in the former case and 49·5 per cent in the latter. A membrane made in a funnel tube, and this filled with copper sulphate solution and placed in water, showed after twenty-four hours a difference of level of 13 cm. and the water without was distinctly blue.—*Ber. Berl. Chem. Ges.*, xi, 2124, Dec. 1878. G. F. B.

2. *On the Action of Hypo-chlorous oxide on Ethylene.*—MULDER and BREMER have studied the action of hypochlorous oxide upon ethylene. A flask filled with fragments of pyrolusite was heated on the water-bath, and strong hydrochloric acid dropped upon it through a syphon. The chlorine thus evolved was con-

ducted through three wide glass tubes each of one-half a liter capacity, containing equal weights of pounded glass and of mercuric oxide, and heated in a sandbath to about 340°. The hypochlorous oxide thus produced was mixed with dry ethylene gas in excess and passed upward through a vertical tube cooled by water and protected from the light. A liquid condensed in the tube which afforded on fractioning a small quantity of ethylene chloride boiling below 100°, but consisted chiefly of a product boiling at 180°-210°, and having a vapor density of 73·8. Analysis gave its empirical composition as $C_4H_6Cl_2O_2$. Fractionated in vacuo, a purer product was obtained. Heated with silver oxide, the filtrate afforded a salt which proved to be silver monochloracetate $CH_2Cl—COOAg$. Heated with water (in which it is not soluble) with an upward condenser, monochloracetic acid was again obtained. After neutralizing the liquid with potassium carbonate, ether extracted from the liquid monochlorhydrin $CH_2Cl—CH_2OH$, boiling at 130°. Hence the action described affords a body having the structural formula $\begin{array}{ccc} CO & — O — & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array}$. The reaction by which this monochlorethyl monochloracetate is produced is

$$\begin{array}{c} CH_2 . CH_2 \\ \| \quad \| \\ CH_2 . CH_2 \end{array} + \left.\begin{array}{c} Cl \\ Cl \end{array}\right\} O = \begin{array}{ccc} CH_2 & —O— & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array}$$

as the first stage; and

$$\begin{array}{ccc} CH_2 & —O— & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array} + \left.\begin{array}{c} Cl \\ Cl \end{array}\right\} O = \begin{array}{ccc} CO & —O— & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array} + (HCl)_2$$

as the second. No products resulting from the action of one molecule of hypochlorous oxide upon one of ethylene appear to be formed.—*Ber. Berl. Chem. Ges.*, xi, 1958, Nov. 1878. G. F. B.

3. *On the Hydrogenation of Benzene.*—The tendency in some quarters to consider benzene as a final hydrocarbon, in consequence of its being the nucleus of the aromatic series, has led BERTHELOT to investigate the action described several years ago by him, by which any unsaturated hydrocarbon may be converted into a saturated one. The method consists simply in treating the hydrocarbon with a saturated solution of hydriodic acid at a temperature of 275° to 280° for some time. In the new experiments, several tubes, each containing 20 c.c. of saturated hydriodic acid and 0·6 c.c. of benzene, were sealed and heated to 270° for twenty hours. The unaltered benzene was removed by fuming nitric acid, and the remaining hydrocarbon, about two thirds of the whole, rectified and analyzed. It was a mixture of C_6H_{10} and C_6H_{12}. A second treatment with hydriodic acid gave nearly pure C_6H_{12}. A third gave a mixture of C_6H_{12} and C_6H_{14}. And finally a fourth treatment gave C_6H_{14} boiling between 68·5° and 70°. This is the final term identical from both the aromatic and the fatty series, the only completely saturated hydrocarbon containing six atoms of hydrogen.—*Ann. Chim. Phys.*, V, xv, 150, Oct. 1878. G. F. B.

4. *On the Action of Hypobromous acid on Ethylene dibromide.*—DEMOLE has been led by theoretical views to study the action

of hypobromous acid on ethylene dibromide. This latter body treated with a strong solution of the acid in excess and agitated for an hour, gave an oily liquid and a supernatant liquid colored by bromine. The latter on examination afforded bromacetic acid. The oil heated in a watch glass for four or five hours, crystallized on cooling, the mass being purified by crystallization from boiling alcohol. It then gave the formula $C_4H_2Br_6O$, and this by its reactions was proved to be an acetone, having its oxygen joined to the carbon by two bonds. On reduction with sodium amalgam, ethyl-methyl-acetone C_4H_8O was obtained, which gave a crystalline compound with hydrosodium sulphite. Hence the first body was hexa-brom-ethyl-methyl-acetone. Oxidized with fuming nitric acid, it yielded malonic acid, easily determined from its properties and those of its barium salt. This shows the structure of the hexa-brom-ethyl-methyl-acetone to be CBr_3—CO—CH_2—CBr_3, the terminal carbon atoms having all the bromine.—*Bull. Soc. Ch.*, II, xxx, 482, Dec. 1878. G. F. B.

5. *Relative Affinities of Oxygen and the Haloid Elements.*—In the October number of the Annales de Chimie et de Physique, Berthelot has a very interesting article on the Relative Affinities and Power of Replacement of Oxygen and the Haloid Elements, and shows that the order of affinity and replacement can be predicted from the amount of heat evolved in the production of the various binary compounds, of which the metals and the metalloids form with oxygen on the one part, and with chlorine, bromine or iodine on the other. In the case of the metals the heat evolved by union with oxygen is with a few exceptions less than that resulting from the union of the same metal with either of the three haloid elements mentioned, and it is shown that in the same measure oxygen may be replaced by the direct action of these elementary substances on the oxides; and further that, in the exceptional cases presented by certain compounds of iodine, where the thermal relations are reversed, the order of affinities—as shown by the replacing power—is reversed as well. Moreover a few other apparent exceptions to the general rule are shown to result from the formation of intermediate products.

While, however, the heat evolved by the combination of the metals with oxygen is less than that resulting from the formation of the corresponding haloid salts, these conditions are, as a rule, reversed in the case of the compounds of the metalloids with the same elements, and so the order of replacement is reversed as well. This is shown to be true in regard to the compounds of phosphorus, arsenic, silicon and boron, and moreover it is made evident that certain anomalies, depending on the production of oxichlorides, are really confirmations of this law of thermo-chemistry, which Berthelot has done so much to establish. The paper is one of great interest, and contains besides the illustration of the important general principle we have stated, the experimental evidence of a large number of new thermo-chemical data. Especially worthy of notice is a new general method of thermo-chem-

istry applied to the determination of the heat of combination of bromide of aluminum, that of chloride of aluminum being known. Thus Al_2Cl_6 is dissolved in water containing 6KBr, and on the other hand Al_2Br_6 is dissolved in the same amount of water containing 6KCl. The difference between the quantities of heat evolved in the two cases gives the only element wanting for calculating exactly the difference between the amounts of heat evolved in the formation of the two anhydrous compounds. Thus

We know from previous investigations that $3(K_2+Br_2$ (gas)+water)=6KBr+Aq. yield .... +285·0 units.
We find by experiment at this time that Al_2Cl_6 dissolved in the previous solution yield .... + 76·0 "
Representing the heat resulting from the union of $Al_2+Cl_6=Al_2Cl_6$ by x
We have for $Al_2Cl_6+6KBr+Aq$. .... $x+361·0$ "
So also we know that $3(K_2+Cl_2+water)=6KCl+Aq$. yield .... +302·4 "
And we find as before that Al_2Br_6 dissolved in this product yields .... + 86·9 "
Representing the heat-form $Al_2+Br_6=Al_2Br_6$ by...y
We have for $Al_2Br_6+6KCl+Aq$. .... $y+389.3$ "

Since the final states of the two resulting solutions seem absolutely the same, it must be that

$$x+361·0=y+389·3$$
$$\text{or } x-y=389·3-361·0=28·3 \text{ units.}$$

If then we adopt for x (when $Al_2+Cl_6=Al_2Cl_6$) +160·9
We have for y (when $Al_2+Br_6=Al_2Br_6$) +132·6

J. P. C.

6. *The Part of Acids in Etherification.*—The effect of the presence, merely, of an inorganic acid in determining the etherification of alcohols by the organic acid has long been known, and the theories advanced to explain this so-called "catalytic" action have been numerous. In a paper following the last, Berthelot seeks to show that these processes also conform to the general "law of maximum works," that is, are the natural result of a tendency to a condition, in which the maximum amount of heat is evolved. To this end both the chemical, and the thermal conditions, involved in both the separate and also the mutual action of hydrochloric and acetic acids on alcohol are fully discussed, and it is shown that in the last case the formation of acetic ether is attended with a much greater evolution of heat than would be that of hydrochloric ether. Hence when the two acids are present, the former and not the latter of these two ethers is the chief product of the reaction, and it is shown that the one condition which chiefly determines the result is the great amount of heat evolved by the solution of HCl gas in an excess of alcohol. It is also shown that this thermal theory gives a satisfactory account of the well known conditions limiting these reactions, and that in the action of a mixture of strong nitric and sulphuric acids on hydrocarbon compounds, similar thermal relations determine the production of nitro- instead of sulpho-derivatives. J. P. C.

7. *Preliminary Note on the Substances which produce the Chromospheric Lines;** by J. NORMAN LOCKYER, F.R.S.—Hitherto, when observations have been made of the lines visible in the sun's chromosphere, by means of the method introduced by Janssen and myself in 1868, the idea has been that we witness in solar storms the ejection of vapors of metallic elements with which we are familiar from the photosphere.

A preliminary discussion of the vast store of observations recorded by the Italian astronomers (chief among them Prof. Tacchini), Prof. Young, and myself, has shown me that this view is in all probability unsound. The lines observed are in almost all cases what I have elsewhere termed and described as *basic lines;* of these I only need for the present refer to the following:

b_3 ascribed by Ångström and Kirchhoff to iron and nickel.
b_4 " " Ångström to magnesium and iron.
5268 by Ångström to cobalt and iron.
5269 " " calcium and iron.
5235 " " cobalt and iron.
5017 " " nickel.
4215 " " calcium, but to strontium by myself.
5416 an unnamed line.

Hence, following out the reasoning employed in my previous paper, the bright lines in the solar chromosphere are chiefly lines due to the not yet isolated bases of the so-called elements, and the solar phenomena in their totality are in all probability due to dissociation at the photospheric level, and association at higher levels. In this way the vertical currents in the solar atmosphere, both ascending and descending, intense absorption in sun-spots, their association with the faculæ, and the apparently continuous spectrum of the corona and its structure, find an easy solution.

We are yet as far as ever from a demonstration of the cause of the variation in the temperature of the sun; but the excess of so-called calcium with minimum sun-spots, and excess of so-called hydrogen with maximum sun-spots follow naturally from the hypothesis, and afford indications that the temperature of the hottest region in the sun closely approximates to that of the reversing layer in stars of the type of Sirius and α Lyræ.

If it be conceded that the existence of these lines in the chromosphere indicates the existence of basic molecules in the sun, it follows that as these lines are also seen generally in the spectra of two different metals in the electric arc, we must be dealing with the bases in the arc also.

8. *Upon the Nature of Spectra of Mixed Gases.*—Prof. E. WIEDEMANN discusses at length the theories of the action of molecular forces in producing various spectra. Certain writers, among whom are Stefan and Van de Waals have supposed the existence of an attracting force between the molecules, and also a repulsive one arising from an ether envelope which surrounds the molecule. The rotation and oscillation of the atoms in the mole-

* Paper read at the Royal Society, London.

cule, which increase to the point of breaking up the molecule into its atoms and which action increases with the temperature, may produce periodic vibrations in the surrounding light ether. Line spectra, on this theory, are produced when, under the influence of heat, the molecules are divided into atoms and an oscillatory vibration is set up. F. Lippich and Pfaundler have shown from a theoretical point of view that the broadening of line spectra may result from the influence of high temperature in producing a motion of the molecules of a gas partly toward and partly away from the observer. Wiedemann examines the views in regard to band spectra and concludes that they cannot be attributed to rotation of the molecules; and that the difference between band and line spectra is not explained on the hypothesis of a change of pressure of the gas under consideration. Wiedemann believes, after consideration of the facts, that the difference between emission and absorption spectra is to be sought in the change of vibration peculiar to each chemical combination, which vibration is modified by surrounding circumstances; and that two different substances can give identical spectra only when the forces acting between the atoms in the molecules are identical. Prof. Wiedemann states his intention to test his theoretical conclusions by experiment and give the results of his preliminary investigation upon the spectra of mixed gases. A Geissler tube containing a small portion of mercury was filled with hydrogen and the tube was heated in an air bath while the current from an induction apparatus passed through it. At ordinary temperatures the hydrogen spectrum was seen; with an increase of temperature appeared that of quicksilver. With increasing temperature the spectrum of the latter grew brighter and brighter, while that of hydrogen disappeared in all parts of the tube. In another trial, sodium was enclosed in hydrogen or nitrogen vapor. Here, also, the spectra of the gases disappeared and at a high temperature only the lines of sodium appeared. The author believes that the disappearance was not due to any new chemical combination into which the substances had entered, and discusses at some length the theory that the passage of electricity from molecule to molecule is to a certain degree selective and that it can call forth certain oscillations or vibrations in certain molecules of one substance while it cannot do so in a neighboring substance which forms a mixture with the first.—*Ann. der Phys. und Chem.*, No. 12, 1878, p. 500. J. T.

9. *The Law of the Telephone.*—M. Hermann, in Archiv für Physiologie, vol, xvi, pp. 264 and 314, has adduced certain experiments to show that M. Dubois Reymond's theory that the action of the telephone can be explained from the general law of induction in which the bending of the iron plate is taken into account and the induction of the current path upon itself is neglected, does not explain the facts observed. Prof. H. F. Weber communicated to the Züricher Naturforschenden Gesellschaft, a paper in which he showed that Hermann's experiments agreed entirely

with the theoretical laws of induction, and that M. du Bois Reymond was wrong in neglecting the induction of the current path upon itself, which last was really the principal agent in producing the agreement between theory and practice. Ten days later M. Helmholtz presented a paper to the Berlin Akademie der Wissenschaften which covered the same ground as Prof. Weber's paper. The general results of these papers are as follows: (1.) "In the telephonic circuit the tone is in general altered." (2.) "The phase-displacement that occurs during the telphonic transit is not a constant quantity, its amount changes with the constitution of the path of the current, and depends on the number of vibrations." (3.) "In certain cases, however, the amplitude of the induced current becomes independent of the vibration number *n* and thus the tone of the exciting sound is unchanged." J. T.

II. Geology and Natural History.

1. *Reports upon the Specimens obtained from borings made in* 1874, *between the Mississippi River and Lake Borgne, at the site proposed for an outlet for Flood Waters;* by Prof. Eugene W. Hilgard and Dr. F. V. Hopkins. With a letter of transmittal from Bvt. Maj. General G. K. Warren, Major of Engineers, President of the Commission. Washington, 1878.—This memoir, of great interest geologically, is from the Supplement to the Report of the Commissioner of Engineers of January 16, 1875, on the Reclamation of the Alluvial Basin of the Mississippi.

Prof. Hilgard published, several years since (Rep. Chief of Engineers, U. S. A., 1870), an account of a section 146 feet deep, made in boring a well at New Orleans in 1856. In it, the part below a depth of 41 feet (numbered in the present pamphlet 1 to 4) was found to contain marine shells, and to consist, below the 112 feet level, of a drab or bluish clay (numbered 1), and (Nos. 2 to 4) marine sandy beds, excepting 3 feet of clay (No. 3); then, from 21 to 41 feet in depth, a blue fluvio-marine clay, here numbered 8; and, at top, 21 feet of fresh-water bluish tough clay, here numbered 11.

In the borings of 1874 referred to in the above title, the same beds were met with. No. 1 was reached in four of them at the depth of 91 to 97 feet, and No. 4, below 57 to 72 feet; both were found to contain numerous marine shells, while the thin clay bed No. 3, appeared to be a fluviatile stratum. No. 4 has afforded the shells *Balanus eburneus*, *Nassa acuta*, *Anachis avara*, *Oliva mutica*, *Utriculus* (*Tornatina*) *biplicatus* (*Bullina canaliculata* of Rep. of 1870), *Pholas costata*, *Pandora trilineata*, *Corbula cuneata*, *Mactra lateralis*, *Tellina alternata*, *T. tenera*, *T. tenta*, *Macoma fusca*, *Chione cancellata*, *Ch. cribraria*, *Dosinia discus*, *Lucina multilineata*, *L. costata*, *Arca transversa*, *Pecten dislocatus*, and other species.

No. 8 was met with in four borings near Lake Borgne between the upper levels 25 to 26 feet, and the lower 52 to 56 feet, in

three others, between the levels 22 to 38 and 64 to 73 feet; and varying much in depth in others. This bed is a *blue delta clay*, the deposit of a tide-water marsh, containing no large marine shells, but an intermingling of marine and fresh-water microscopic forms, the latter increasing in number landward. The evidence shows that it was traversed by streams.

Above No. 8, the next marked beds are Nos. 11 and 12, of which No. 11 is a cypress-swamp deposit, and 12, a sea-marsh clay, both still in progress. Dr. Hopkins gives a list of the microscopic organisms of strata Nos. 8 and 12 with notes and figures, and points out the fact that there is a marked difference between them. Among the species in No. 8 there are *Grammostomum Americanum*, *Lenticulum discus*, *Rosalina Beccarii*, *Navicula Gundleri*, *Pinnularia viridis*, *Eunotia gibberula*, *Coscinodiscus radiatus*, *Leptocistinenia Kinahani*; and in No. 4, *Rotalia pachypleura*, *Planulina elegans*, *Navicula fulva*, *N. viridis*, species of *Rhizosolenia*, *Nitzschea*, *Globigerina*, etc. The two have in common *Orbulina universa*, *Melosira distans*, *Cocconema lanceolatum*, *Synedra acuta*. Prof. Hilgard remarks:

"Stratum 8 may be a true delta deposit of the present Mississippi, such as it has been since the re-elevation of the continent which determined the erosion of the present trough of the river. The fact that an apparently fluviatile stratum (No. 3) occurs lower down, may be taken as an indication that both Nos. 2 and 4 fall within the modern period of delta formation. Yet it is not to be supposed that during the period of depression some definite channels, such as that indicated by strata Nos. 2 and 7, did not exist here as well as in the region above, at Port Hudson (Smithsonian Contr. No. 248, p. 5), and elsewhere. But in a 'drowned' delta in course of depression, such channels would, on the whole, be smaller, shallower, and more shifting than during the period of elevation, or the quiescent one that now prevails."

"On the other hand, stratum No. 8 might be regarded as the denuded remnant of a much thicker stratum deposited during the period of depression, and therefore sensibly contemporaneous with the 'Port Hudson clay.' If, as seems probable, it extends to seaward beneath the water of Lake Borgne, it is difficult to conceive it otherwise than as the continuation of the 'blue-clay bottom' of Mississippi Sound, about whose antiquity, and connection with the Port Hudson beds proper, there can scarcely be a question. But until actual examination shall have determined these points, and especially the microscopic similarity of the 'blue-clay bottom' to stratum 8, speculation as to how the latter came to occupy its present position can hardly lead to any useful conclusions."

"It was not, of course, to be expected that borings reaching only to a depth not greater than that sometimes attained by the Mississippi River itself, should throw any direct light on the question of the depth of the delta deposits in the upper delta plain. Yet, in so far as the results of the present investigation

corroborate the steady and rapid increase of the marine character as we descend, as well as an appreciable difference of the fauna from that now ordinarily thrown ashore on the delta beaches, they tend to corroborate also my previous conclusion that the delta deposits proper, at least at and above New Orleans, have a comparatively inconsiderable thickness; and that this anomalous structure of the delta of the great river is in direct causal connection with the equally anomalous phenomenon of the mud-lumps."

The memoir contains, besides a map and sections, three plates of fossils; two by Dr. Hopkins, representing the microscopic organisms obtained from the various beds, the upper as well as the lower, and one of larger fossils by Hilgard. Among the latter Prof. Hilgard names, as probably new species, *Serpula fenestrata*, *Turbonilla undecim-sulcata*, *Dentalium læve*, *D. sexangulare*, *Cardium æquilaterale*, and *C. inæquilaterale*.

2. *The Question of the Gonidia of Lichens.*—The discussion opened by the well-known Alternative of De Bary (Morph. and Phys. d. Pilze, etc., p. 291), to which Schwendener gave such prominence, and which Bornet has especially illustrated, has been brought at length to what looks like a conclusion by the observations of Dr. Arthur Minks, of Stettin.

The early *dictum* of Fries, that, however related the Lichens may be to the Algæ by their vegetation, they are Fungi as regards their fruit, was brought to mind again, more than fifty years later, by the just cited pregnant remarks of Professor De Bary, on the relation of the Nostochaceæ and Chroococcaceæ to the Lichens, which he winds up with the (freely rendered) following observation. It is scarcely then, he says, to be doubted that a large part of these families of Algæ stand in near genetic relation to the Jelly-lichens, Ephebe, etc. In what relation, it remains to ascertain. Briefly to indicate my opinion, two suppositions appear to present themselves: Either the Lichens we have spoken of are the perfectly developed fructifying states of plants, the imperfectly developed conditions of which ranked heretofore as Nostochaceæ and Chroococcaceæ, among the Algæ—or the groups last named are typical Algæ, which assume the form of Collema, Ephebe, etc., in consequence of being penetrated by certain parasitical Ascomycetes, which spread their mycelial cells through, and thus condition the growing thallus. (De Bary, as above.) Now there appears to be no doubt that these green cells of Lichens (gonidia) are in exactly the indicated relation to the similar cells of the Algæ named, or that the Lichen fruit is equally in accord with certain Fungus fruits—whatever explanation of either fact be attempted. And Professor Schwendener first took up the consideration of the question from this definite ground: If, said he, at the end of the last of his papers on the anatomy of the thallus, in Naegeli's Beiträge, 1868, p. 195, the possibility of such a process as is indicated in the second supposition of De Bary, and in certain cases even the probability of it, can no longer be impugned, the inquiry forces

itself upon us whether it be not possible that all Lichens arise in this way; whether the gonidia be not always to be reckoned typical Algæ, and the colorless thread-cells, in like manner, Fungus-hyphæ. And, after following the consideration of this through several pages he concludes with the remark that, whatever weight be conceded to what he has advanced, it is impossible to deny that the acceptance by way of hypothesis of such parasitic action is authorized by what we know, and that the question deserves, therefore, a thorough investigation. This, Schwendener himself took up the next year (Die Algen-typen der Flechten-Gonidien, 1869), and has also published, besides shorter papers which I am not now able to refer to their places of publication, Erörterungen der Gonidien-frage, 1872, since which he has not returned to the inquiry in print. It has been continued, however, with great interest by others, and if lichenologists have generally looked askance at it, physiologists have done their best, we may say, to show it favor.

Known already among lichenologists by studies of the most sincere and thorough kind—of which I will refer only to his Beiträge z. Kenntniss des Baues u. Lebens der Flechten, pp. 126, and two plates, 1876—Dr. Minks has specially directed his more recent efforts to the resolution of the problem of Schwendener. It had sometimes seemed as if the general, more or less harsh and subjective criticism which makes so large a part of even scientific controversy had been all on one side in this debate, and the pure struggle for objective truth almost altogether on the other; and the interest of unprejudiced observers could hardly fail to attach itself to the last, whether ridiculously aspersed as "notorious" or not. It was yet evident in the *Culturversuchen*, as well of Tulasne as of the later experimenters, especially Reess and Stahl, that elements of uncertainty not conceivably to be eliminated, infected these experiments, and it began to be doubtful whether final results could be looked for by this or, indeed, any other tried way of approach: or, whether the systematic exhibition of Schwendener's hypothesis by Sachs (Lehrbuch, edit. 3, 1873, p. 267) could well expect any satisfactory proof.

Most interesting was it therefore to every student of the Lichens that the keen observer to whom we have referred should buckle to the contest in the most weighty dispute that ever arose in this humble realm of vegetable nature. The long-promised second part of Dr. Minks's Beiträge, with full illustrative plates, has not yet however made its appearance here, and we have only an abstract of the treatise, given by the author in the Regensburg Flora, 1878, to refer to. This is, however, sufficient to indicate the importance of the author's results. It is with the microscopic history of those very minute, often green cells, which have received the name of microgonidia, that this paper is mainly occupied. The cells in question owe their name, as also a recognition of their importance in the question, to Kœrber (Zur Abwehr der Schwendener-Bornetschen Flechtentheorie, 1874), but the whole remarkable exhibition of

their real character and history, to the sufficient microscope, and the patient skill of Dr. Minks; who has thus shown that the lichenologists are quite right, and that the gonidium is plainly a modification of the one (ideal) lichen-cell, in the distinction of which from the fungus-cell it may still be taken for a criterium. The first beginning of the microgonidium, as observed in the hyphæ, is a pale-greenish, broken axial column, passing into irregular strings of rounded masses of protoplasm, which finally acquire the cell-wall and whole structure of gonidia, and escaping from the mother-cell are found free, in every degree of intermediate form between microgonidium and gonidium. No distinction between these two appears, except in size or color; and they characterize in their earliest conditions, we have finally to say, every modification whatever of the lichen-cell, which thus bears witness everywhere (to the sufficiently armed and instructed eye) to its natural autonomy.

Owing in part to the peculiar texture of the lichen he had in hand, Dr. Minks, whose observations were made with a power of about 1250 diameters, laid much stress on the preparation of his material with liquor potassæ and sulphuric acid; but Dr. Müller of Geneva, who has repeated the observations of Minks, and with more powerful objectives (Flora, 1878, n. 31) finds that such chemical preparation is by no means always necessary; to which I can myself testify. Microgonidia were seen by Müller in every part of the lichen structure; namely, in the fibrils of the under side, in the cortical cells, in the medullary cells, in the paraphyses, the young thekes, the spores, the basidia, and the spermatia.

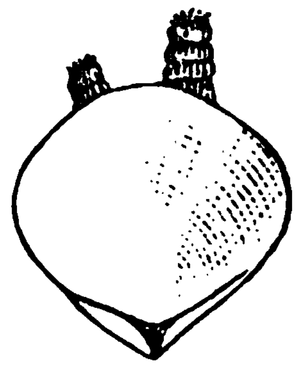
After many unsatisfactory attempts, with dry objectives, and inferior powers, but with some attention to chemical preparation of the material, I have had at last the pleasure, with an immersion $\frac{1}{8}$ of Tolles, to clearly discern the pale-greenish, broken column, passing into rounded, microgonidium-like masses, contained in, and seen at length to escape from, the medullary hyphæ of the Parmelia of Wright Lich. Cub. n. 74 (there called by me *P. tiliacea*, v. *flavicans*, and supposed the same with the *P. relicina*, at least of Montagne) reaching this result with a power of only some six hundred diameters, and without other preparation than a thorough maceration of the tissue in water. With a $\frac{1}{10}$ of Tolles, a 1-inch eye-piece, and power of about 1,000, the whole structure and especially the color was better exhibited; as it was, I need not say, best of all in Tolles's admirable $\frac{1}{18}$ and $\frac{1}{25}$. These observations have all been repeated by my friend Mr. Stodder, with similar results, and I owe entirely to him the manipulation of the two objectives of highest power.

I have only then most heartily to commend to botanists interested, the forthcoming treatise of Dr. Minks, which may soon be expected to appear. E. TUCKERMAN.

3. *Etudes Phycologiques*, by M. GUSTAVE THURET and Dr. EDOUARD BORNET. Fol. Paris, 1878.—This magnificent work surpasses anything which has ever been published relating to

algæ. It comprises fifty-one folio engravings by Picart from drawings of Bornet and Riocreux. Most of the plates were prepared under Thuret's direction between the years 1846 and 1856, and several appeared in a reduced form in the Annales des Sciences of 1851 as illustrations of his article "Recherches sur les Zoöspores des Algues." It was Thuret's intention to publish an atlas of fifty plates, but, at the time of his premature death, ten of the plates had not been engraved. These were finished under the direction of his friend and co-worker, Dr. Bornet. Never before have the algæ been so exquisitely delineated, whether microscopically or in gross. The life-size figure of *Fucus platycarpus* is perfection itself. The text is principally by Dr. Bornet, who has inserted when possible the notes and descriptions of Thuret himself. No apology, however, was necessary on the part of the former; for not only was he the constant companion of Thuret, but his style of writing very closely resembles that of his lamented associate. The text modestly purports to be simply a description of the plates. It is, however, much more: it is a very elaborate exposition of the structure and reproduction of the different groups of algæ. The principal part of the observations on the *Fucaceæ* have already appeared in the Annales. The part relating to the *Phæosporeæ* is very clearly presented, and is the most complete account of the order yet published. The fertilization of *Polyides rotundus* resembles that of *Dudresnaya* in the growth of a number of filaments from the base of the trichogyne. The account of the reproduction in the *Corallineæ* throws a new light on the structure of that order; and for the first time a detailed account is given of the antheridia and cystocorpic spores. W. G. F.

4. *Note on the extension of the coiled arms in Rhynchonella;* by EDWARD S. MORSE.—Years ago Von Buch recorded that Otto Frederic Müller had observed *Rhynchonella psittacea* protrude its arms beyond the anterior borders of the shell. This single observation was not widely accepted, and many doubted the possibility of the arms being exserted in this manner. In the year 1872, while studying living Rhynchonella in the St. Lawrence, I observed a specimen protrude its arms to a distance of four centimeters beyond the anterior borders of the shell, a distance nearly equaling twice the length of the shell. This year I again had an opportunity of studying Rhynchonella in Hakodate, Yesso, and again observed the same features. Specimens lying on the bottom of a glass dish protruded their arms a short distance and remained in this position for hours. A figure is here given representing the appearance of one of them. The movements of the arms were very sluggish though the cirri were constantly in motion. Sometimes the shells closed upon the arms before they were retracted. Lingula has the power of partially protruding its arms, as I have repeatedly observed in North Carolina and Japanese species. Terebratulina can also partially protrude the cirri.



Tokio, Japan, November 26, 1878.

5. *Fauna Littoralis Norvegiæ;* edited by J. KOREN and Dr. D. C. DANIELSSEN. Part III, with 16 plates. Bergen, 1877.—This volume, which, as stated by the editors, has been delayed several years, contains much that is of importance in connection with our own marine fauna, for many of the species, very fully described and figured in it, inhabit, also, the coasts of New England, although in many instances their identity has not yet been pointed out. The text is printed in both Danish and English, in parallel columns. The subjects treated are as follows: New and little known Cœlenterates, by M. Sars; New Echinoderms, by M. Sars; Descriptions of some new Norwegian Cœlenterates, by Koren and Danielssen; Contributions to the natural history of the Pennatulidæ living on the Norwegian Coast; Descriptions of new Bryozoa; Contributions to the natural history of the Norwegian Gephyreæ; a New species of the genus *Pennella* (*P. balænopteræ*). The last four articles are by Koren and Danielssen. Among the Cœlenterata described, are species of *Corymorpha*, *Myriothela*, *Physophora*, *Phellia*, *Zoanthus* and *Alcyonium*. A list of all the Norwegian Pennatulidæ is given, with descriptions of three new genera and six new species of that group. Of the Norwegian Pennatulidæ at least three species inhabit our coast, viz: *Ptilella grandis*=*Pennatula borealis* Sars; *Pennatula aculeata*; *Pavonaria* (=*Balticina*) *Finmarchica*. The *Alcyonium fruticosum* Sars appears to be identical with our common *A. carneum* Agassiz, of earlier date. The *Corymorpha glacialis* Sars is apparently the same as *C. pendula* Agassiz, of later date. Two very different forms, figured as *Myriothela phrygia*, are supposed to represent different stages of growth. The form with gonophores borne on simple elongated, lateral blastostyles is allied to that recently described by me, in this Journal, as *Blastothela rosea*, and may prove to be generically identical with it. The other form has gonophores borne in groups directly upon the hydroid-body. I have dredged a similar form in Eastport harbor. Whether either of these forms, is the original *Lucernaria phrygia* of Fabricius,* is perhaps doubtful. The *Zoanthus Norvegicus* D. and Kor. is probably the same as my *Epizoanthus Americanus*

* We have, on our coast, another form, which agrees better than either of those here referred to, with the Fabrician description. A specimen dredged off Halifax, N. S., in 52 fathoms, 1877, is about three inches (75^{mm}) high, as preserved in alcohol. The tentaculiferous portion is long and slender, densely covered with slender, rather elongated, capitate tentacles. The gonophores are globular, large, (when mature 2^{mm} in diameter) and are borne in clusters of three to ten, on the sides of lateral blastostyles, of different lengths, each of which bears, at its tapering end, a small group of capitate tentacles, unequal in size. These blastostyles, with their clusters of gonophores, cover less than the lower third of the body. The gonophores near the bases of the blastostyles are much smaller, there being usually only two or three large ones. The mature gonophores contain embryos, covered with tentacles, like those described by Sars. (The embryos of *Blastothela rosea* V. are of the same kind, but smaller). The base gives rise to a numerous cluster of short, slender processes, enlarged at the ends, with adhesive disks for attachment. I believe that this is the genuine *phrygia* of Fabricius, and that the forms described by Sars (originally as *M. arctica*) will prove to be distinct, if the figures be correct.

(1864). Of the Echinoderms, *Oligotrochus vitreus* Sars has been recorded by me, in this Journal, as from deep water, off our coast, and I have also dredged it off Nova Scotia (1877).

The genus *Kinetoskias* is established for two very remarkable forms of Polyzoa, both of which have been dredged by us, off the New England coast. One of these (*K. Smittii*) is identical with *Bugula flexilis*, described and figured by me in this Journal, (vol. ix, p. 415, pl. vii, f. 1, 2, 1875) and probably, also, with the *Naresia cyathus*, figured and partially described by Thompson in the Voyage of the Challenger (vol. i, p. 142). The specimens hitherto noticed have all been attached to the summit of a slender transparent stem, which is regarded both by Thompson and by Koren and Danielssen, as a part of the Polyzoan itself. The numerous specimens dredged by me are, also, for the most part, attached to a stem of the same sort, but varying much in size and condition. They occur chiefly on muddy bottoms, in 50 to 430 fathoms, in many localities, *associated with Corymorpha pendula*, and their "stems" appear to be identical with the dead stems of *Corymorpha*, and like the latter, often have many anchoring rootlets arising from the swollen base. In one instance a small *Sertularia* had attached itself to the same sort of a stem, and the Polyozoan had afterwards attached itself to, and invested, both the *Sertularia* and the supposed *Corymorpha*-stem! Therefore I am led to conclude that the "stem" does not form an integral part of the Polyzoan. Nevertheless its structure is, in other respects, so peculiar as to justify its separation from *Bugula*, as a distinct genus. The second species (*K. arborescens*=*Bugula umbella* Smitt) was dredged by us in 1877, off Halifax, N. S., in 110 fathoms, sandy mud. The article on Gephyreæ is a useful monograph of the Norwegian species, several of which are also found on the New England coast. A. E. VERRILL.

III. ASTRONOMY.

1. *Observatory on Mt. Etna.* Letter to the Editors from Professor S. P. LANGLEY, dated Casa del Bosco, Mt. Etna, January 14, 1879.—You may be interested to learn that the proposed Etnean observatory will probably be commenced in the present year on the site of the "Casa Inglese," a hut used by summer visitors to the volcano, and standing at the foot of the cone, at an elevation of over 9,600 feet. The walls and piers will be constructed chiefly of lava and the building is intended to include the "Casa Inglese," and in addition three other rooms, one of which, containing the equatorial, is to have a conical rotary roof of iron; the others are to be used as a kitchen and bedroom. The equatorial is to be of thirty-five centimeters aperture. It will be seen that the new physical observatory is to be well provided instrumentally. It will be under the eminently competent charge of Professor Tacchini of Palermo; and it will have a situation unequalled by any site at present so occupied in the world.

Science is indebted for this prospective benefit, to Professor Tacchini himself, who has long urged upon his Government the paramount importance of an elevated station for the study of solar physics, and has, it may be observed, cited the brilliant results obtained by our own Professor Young at Sherman as his most convincing proof of the advantage of mountain stations. I write in the hope that the example thus set by Italy may find imitators with us. I have been now for some time at a less high but still an elevated station here (Casa del Bosco is a hut ordinarily unoccupied, about 4,500 feet above the sea), engaged in observations, which it may be hoped will be of some use in determining what may be expected in similar sites in our own territory, their aim being to substitute some sort of quantitative data, for our present conjectural knowledge, as to the degree in which the conditions of vision are improved at higher stations, and to form with something of definiteness a standard of comparison. The results (which will probably appear in a report presented to the U. S. Coast Survey) are not as yet complete; but I may say, in general terms, that while as regards observations of precision (perhaps even as regards work on double stars, and like measures), the gain is less than might have been expected, too much can hardly be said of the immense advantage of an elevated station for almost every kind of research connected with solar physics. This is specially the case as regards the chromosphere; while, as to the corona, concededly, our only hope (with our present means) of materially extending our knowledge of it, lies in the prospect that we may yet be able to see it without an eclipse, if the observer be in an exceptionally transparent atmosphere. I will add that, after a recent expedition to Colorado, and with the conditions of observation there and here freshly in mind, I have no hesitation in saying that our own country has sites at the least equal to the proposed Etnean station in every astronomical requisite, and far easier of access. It is most earnestly to be hoped that something will be done with us in this direction *soon*, even if on a very moderate scale. If we wait for such a distant event as the completion of the Lick Observatory, we shall find the laurels gathered by European observers before we are upon the field.

IV. Miscellaneous Scientific Intelligence.

1. *Earthquake of November* 18, 1878.—In regard to this earthquake (already noticed, vol. xvii, p. 158, Feb., 1879), a special Bulletin from Prof. Nipher, Director of the Missouri Weather Service, dated January 1, 1879, gives the following particulars:

"The shock was felt over an area of fully 150,000 square miles. The region disturbed forms an ellipse, the major axis of which extends from Leavenworth, Ks., to Tuscaloosa, Ala., a distance of over 600 miles. The minor axis extends from near Clarksville, Ark., to a point midway between Cairo, Ill., and St. Louis, a distance of 300 miles. The southern boundary of this region has not been determined with as great accuracy as is desired. The region

: greatest disturbance was along the Mississippi, from Cairo to .emphis. Here the shocks were universally felt. The walls of ıildings could be seen to move, and strong frame buildings 'eaked, as when every joint is strained by a heavy wind. At onton, the shock was also so severe as to alarm some who lived brick houses. Along the Missouri, from Glasgow to Lexington, ıe shock was also severe, awakening many families who thought wind storm was in progress. It appears that the shock was first lt at Glasgow $11^h\ 23^m$ P. M. (St. Louis time). The shock traveled .pidly down the axis of the ellipse, reaching Cairo at $11^h\ 48^m$ ıd Memphis at $11^h\ 50^m$. The velocity of transmission is a matter ɪt under consideration, and will receive attention in a future ılletin. At Little Rock, Ark., the shock was also felt, although ɪt observed at Clarksville, 35 miles farther up the river."

The bulletin is accompanied by a map of the district, on which ıd within the ellipse referred to above, there are marked twenty-ree stations where the shock was felt and eleven Missouri stations here it was not felt. From this map the direction appears to ıve been N.W. to S.E. instead of N. to S. as stated in our 'evious notice. C. G. R.

A second Bulletin in regard to this earthquake has been issued r Prof. Nipher. In it he says:—

"According to the few determinations of time made, there were 'o distinct centers of disturbance, the shock beginning at the ıe, near Glasgow, Missouri, at $11^h\ 23^m$ P. M.; at the other near ıducah, Kentucky, at $11^h\ 34^m$ P. M. (St. Louis time).

The following times are deemed reliable:

Glasgow Region.		Intermediate.		Paducah Region.	
ısgow	11^h23^m	St. Louis	11^h57^m	Paducah, Ky.	11^h34^m
avenworth	11-34	Ironton	11-45 to 11-50	Charleston, Mo.	11-45
xington	11-38			Cairo, Ill.	11-48
ıcon	11-38			Memphis, Tenn.	11-49
		Lebanon	12-19		
		Little Rock	12-13		

'ith so few data, it is only possible to give approximate deter-ınations of velocity, as the wave fronts can not be determined ıth precision. The average velocity was probably less than 200 ıles per hour. In some regions the velocity was as low as 160 ıles per hour.

Direction of vibrations: Paducah, N.W.–S.E. (Chandelier), ıiro, W.N.W.–E.S.E., Charleston, N.–S., Little Rock, E.–W., lasgow, N.–S., by some, N.W.–S.E. by others. At Ironton the mbling sound accompanying the shock, seemed to go *from to N.* A similar sound was heard at Gayoso, Missouri, and emphis, Tennessee. The shock seems to have been more violent the New Madrid region as far south as Memphis, than in the lasgow region."

The Bulletin is accompanied by a map, showing the regions fected as above, and also the neighboring field of the earth-ıake of Nov. 15, 1877. C. G. R.

2. *Forschungen auf dem Gebiete der Agrikulturphysik.* Herausgegeben von Dr. E. WOLLNY, Professor der Landwirthschaft in München. Band i, 482 pp., and Band ii, 1 and 2 Hefte. Heidelberg: C. Winter.—This excellent journal of agricultural physics, which has entered on its second year, fills a very necessary place in scientific literature. Some of the more important questions in agriculture are largely or purely physical, and demand special study as such. Their investigation will be greatly stimulated and promoted by the existence of an organ in which the hitherto scattered results of research are brought together. The seven numbers of this journal before us contain not only valuable original papers on various subjects belonging to the physics of the soil, the plant and the atmosphere, but in the careful discussions of older investigations, give instructive reviews of nearly all that has been done in several branches of these subjects. The contributions of the editor, Dr. Wollny, on the influence of the color, exposure and texture of the soil, on its temperature, are models of experimental investigation. The original articles are supplemented by abstracts of papers elsewhere printed, and by lists of publications. S. W. J.

3. *The American Journal of Otology:* a quarterly Journal of Physiological Acoustics and Aural Surgery; edited by Clarence J. Blake, M.D., in conjunction with Prof. A. M. Mayer, Dr. Albert H. Buck, Dr. Samuel Sexton, Dr. C. H. Burnett, Dr. J. Orne Green and Dr. H. N. Spencer. Vol. i, No. 1, January, 1879. New York (William Wood & Co.).—This new journal proposes to fill a new and highly important place among American scientific periodicals. The first number contains among others an article on the graphic and photographic illustration of Sound-waves, by Dr. C. J. Blake.

The following books have been received but cannot be noticed in this number:

Wanderings in South America, the North-west of the United States and the Antilles in the years 1812, 1816, 1820 and 1824, by Charles Waterton; new edition, edited by the Rev. J. G. Wood. 520 pp. 8vo. London, 1879 (Macmillan & Co.)

Journal of a Tour in Morocco and the Great Atlas, by Joseph Dalton Hooker and John Ball; with an Appendix by George Maw. 499 pp. 8vo. London, 1878 (Macmillan & Co.)

The Study of Rocks: an elementary Text-book of Petrology, by Frank Rutley, F.G.S. 319 pp. 12mo. London, 1879 (Longmans, Green & Co.)

Ordnance Notes, No. xc. Measurements of Powder Pressures in Cannon by means of the registered compression of oil: experiments by Dr. W. E. Woodbridge, at Washington Arsenal in 1854–55. Washington, Nov. 20, 1878.

Revue de Géologie pour les Années 1876 et 1877; par M. Delesse et M. de Lapperent. Vol. xv, 229 pp. 8vo. Paris, 1879.

Geological Survey of Pennsylvania: Report of Progress in the Juniata District on the Fossil Iron Ore beds of Middle Pennsylvania, by John H. Dewees; with a Report of the Aughwick Valley and East Broad Top District, by C. A. Ashburner. 305 pp. 8vo. Harrisburg, 1878.

Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. Vol. v, Nos. 8, 9 and 10. Reports on the Dredging Operations of the U. S. Coast Survey steamer "Blake." Description of Sounding-machine, water-bottle and detacher, by Lieut.-Commander C. D. Sigsbee, U. S. N.; pp. 169–179. Echini, by A. Agassiz. Corals and Crinoids, by L. F. de Pourtalès. Ophiurans, by T. Lyman; pp. 181–238. Hydroida, by S. F. Clark; pp. 239–252.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXI.—DR. JACOB BIGELOW.

DR. JACOB BIGELOW died, at his residence in Boston, on the 10th of January last, near the close of the ninety-second year of his age.

While we would pay the tribute due to his memory as by far the most venerable of American botanists, the last survivor of a school in this country which culminated half a century ago, it should also be remembered that he was even at that time distinguished in other scientific avocations, and that from middle to old age he was among the most eminent of physicians. It is not often that we can contemplate a life so long, so richly various, and so well-rounded as his. He was born in Sudbury, Mass., on the 27th of February, 1787; and his father was the minister of the town. That almost goes without saying, most of our distinguished professional men of his and the preceding generations in New England having been the sons of country ministers. He was graduated at Harvard College in the year 1806, Alexander H. Everett and the late Dr. J. G. Cogswell being among the most notable of his class-mates, all of whom he long survived. He directly took up the study of medicine, was licensed as a practitioner in 1809, and after attending one course of lectures in Philadelphia, took his degree of M.D. at Harvard in the year 1810, and established himself in Boston. There he was a practicing physician for about sixty years, and since the death of his senior, Dr. James Jackson, probably the most eminent one. What turned his attention to botany we know not. He early showed an abiding taste for poetry. His commencement part was a poem, and he delivered a *Φ. B. K.*

poem not long after. At about the same time, however, he gave a course of popular botanical lectures in Boston, in connection with Professor Peck, who must have been installed as Natural History professor at Cambridge while Dr. Bigelow was a medical student. The latter possessed the gift of exposition which Dr. Peck lacked; and it naturally came to pass that Dr. Bigelow repeated this course of lectures alone for a year or two afterward.

In the spring of 1814 he brought out the first edition of his *Florula Bostoniensis*, the book which, mainly in its second edition, has been the manual for New England herborization down to a recent day, or rather to a day which seems to us recent. The original volume, of 268 octavo pages, describes the plants which "have been collected during the two last seasons in the vicinity of Boston, within a circuit of from five to ten miles," exceeding those limits only in the case of Magnolia (from Manchester) and one or two more remarkable plants. We know of no other Flora of the kind which was prepared so quickly and so well. The characters are short diagnoses, and in good part compiled. But the descriptive matter must have been original; and it shows that aptitude for seizing the best points of character or most available distinctions, and of indicating them in few and clear words, which has made this manual so deservedly popular. Similar merits distinguish, on its botanical side, Dr. Bigelow's American Medical Botany, a quarto work which was published, in three parts or volumes, between 1817 and 1821, with colored plates—at that time thought to be very good ones indeed—of the principal medicinal plants of the country. He also brought out an American edition of Sir James Edward Smith's Introduction to Botany; and his botanical knowledge, along with that of the materia medica generally and his classical scholarship, placed him at the head, or at the laboring oar, of the committee which in 1820 formed the American Pharmacopœia. The writer used this volume in his medical-student days, and remembers dimly how the account of minor preparations, coming down to jams and conserves, ended with the classical "Jam satis est mihi."

The second edition of the Florula Bostoniensis, published in 1824, while retaining its modest title, was nearly doubled in size and in the number of plants contained, the whole area of New England being included; and it became the Manual of Botany for the region. What a popular and satisfactory work it was, especially to hundreds of amateur botanists, some still living may testify. The third and last edition, issued in 1840, was a reprint, with various additions and corrections, furnished mainly by those who had learned their botany from the preceding one. This is the last Flora or Manual of this and perhaps

any other country, arranged upon the Linnæan artificial system. Much later in life the author contemplated a revision of the work, brought up to the time, and illustrated by chromo-lithographic plates, such as we have lately seen turned to good account. But after some consideration the project was abandoned. He did not propose himself to undertake the editorial work: for he had long since passed from actual service into the *emeritus* or honorary rank of botanists; and his active professional life, already verging to its close, was diversified or relieved by other avocations. Indeed some of these were taken up very early. He became Rumford Professor of the Applications at Cambridge in 1816, and delivered annual courses of lectures until 1827, when he published the substance of them in a volume entitled Elements of Technology, here coining this apt word. During all this time, and much longer, he was Professor of Materia Medica in the medical school of Harvard University, namely, from 1815 to 1855; for many of these years one of the physicians of the Massachusetts General Hospital; through all of them, and until old age disabled him, a leading physician of Boston. From the year 1847 to 1863 he was President of the American Academy of Arts and Sciences, of which body he was a member for sixty-seven years!

We cannot here refer to Dr. Bigelow's various professional and literary writings. They are not numerous, but are weighty. His treatise on "Nature in Disease," which contains the famous discourse "On Self-limited Disease," is the most important of them; and an address "On the Limits of Education," delivered in the year 1865 before the Massachusetts Institute of Technology, is notable. It has been said of the latter, that never before was the depreciation of classical study or general culture, as a preparation for technical scientific education, undertaken by so ripe a classical scholar or so wide-cultured a man. His many essays in English and Latin verse, some of which have been privately printed, ought to be collected. Dr. Bigelow lived, honored and trusted, to a good old age before infirmities touched his frame, and only toward the close was the brightness of his acute mind dimmed. The candle at length burnt down, the flame flickered awhile in the socket, and the light went out.

The name will abide in botanical nomenclature. First appeared in Rees' Cyclopedia the *Bigelowia* of Smith, founded on the *Adelia* of Michaux. But that is *Forestiera.* Then Sprengel, in 1821, founded a genus *Bigelovia* on a Brazilian plant which he took to be a Rhamnacea; but it is a species of *Casearia.* Again, in 1824, Sprengel gave the name to a part of *Spermacoce,* the *Borreria* of G. Meyer. Then DeCandolle, in 1824, was

proposing a *Bigelowia* on *Solea concolor*, of our own New England, as the Prodromus records, when he found that he had to refer it to *Noisettia.* Lastly, in 1836, DeCandolle bestowed the name of *Bigelowia* upon some golden-flowered Compositæ of the Southern United States, which had borne the name of an Old World genus, *Chrysocoma* (Anglice, Golden-tuft), and he added the complimentary phrase: "A Chrysocoma separatum dicavi cl. J. Bigelow qui floræ Americanæ auream coronam flora Bostoniensi et medica addidit." Although this genus was founded upon only two or three species, it has been vastly extended by the exploration of the western regions of our country, where it forms a conspicuous and characteristic portion of the low shrubby vegetation. More than thirty North American species of *Bigelovia*, besides one of Mexico and two of the Andes of South America, now commemorate our venerable late associate. Most of them were introduced to the genus by the present writer. A. G.

ART. XXXII.—*The Vertebræ of Recent Birds;* by Professor O. C. MARSH.

ONE of the most marked features in the skeleton of modern birds is the form of their vertebræ. This is so peculiar and so constant that it is considered by many anatomists to be the best distinctive character for the class. In no other group of animals known is there an approach to the saddle-shaped articulation of the centra seen in the vertebræ of birds.

Not only do the presacral vertebræ of all existing birds exhibit this structure, but the many extinct forms now known from the whole series of Tertiary deposits have the same articulation. If we knew only these fossil forms, in addition to the existing species of birds, the origin of this peculiar vertebral articulation would perhaps remain a mystery. Most fortunately, however, a few Cretaceous birds have been discovered which throw much light on this point, and virtually explain the difficulty.

In the toothed birds *Ichthyornis* and *Hesperornis*, we have two widely divergent forms. The latter was a huge swimming bird, without wings, and with vertebræ corresponding fully to the modern ornithic type. *Ichthyornis*, on the other hand, was a small bird, with great powers of flight, and with biconcave vertebræ, as in Fishes and Amphibians, and in a few Reptiles. The marked contrast between the shape of the vertebral articulation in these two genera is seen in the figures below, which show a characteristic cervical vertebra in each form.

In the vertebra of *Ichthyornis* shown in figures 1 and 2, it will be seen that the articulation of the centrum is cup-shaped; while in the corresponding vertebra of *Hesperornis*, the ends of the centrum are saddle-shaped, as in ordinary birds. Thus the distinction between the two types in this part of the skeleton is as wide as between *Ichthyornis* and any living bird.

To the evolutionist, who believes that birds are all closely connected genetically, this difference in structure, at first sight, offers a most serious difficulty; since hitherto we have had no hint of a transformation from the one form to the other, and no explanation of the origin of the modern vertebræ of birds.

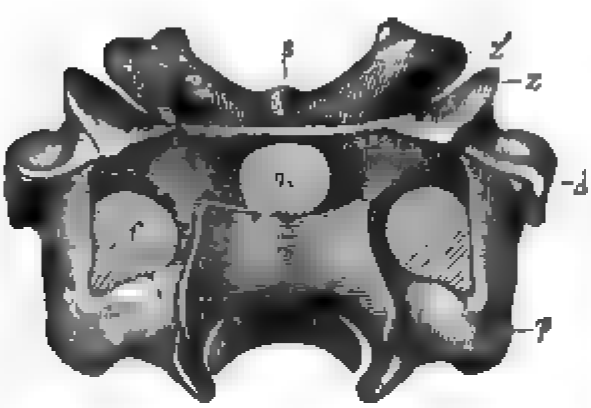
1.

2.

3.

Figure 1.—Twelfth (?) cervical vertebra of *Ichthyornis dispar*, Marsh; front view; twice natural size.
Figure 2.—The same vertebra; seen from the left side.
Figure 3.—Third cervical vertebra of *Ichthyornis victor*, Marsh; front view; twice natural size.

4.



5.

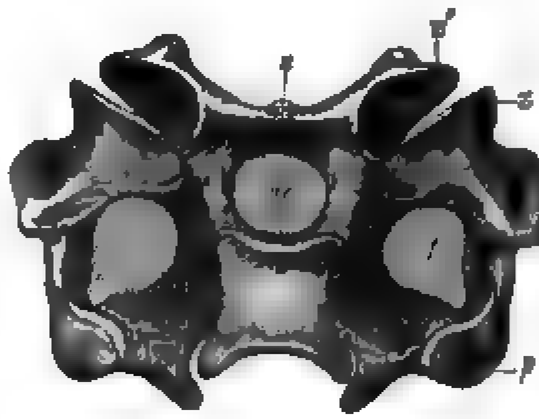


Figure 4.—Thirteenth cervical vertebra of *Hesperornis regalis*, Marsh; front view; natural size.
Figure 5.—The same vertebra; posterior view.
a. anterior articulation; *d.* diapophysis; *p.* parapophysis; *f.* lateral foramen; *nc.* neural canal; *s.* neural spine; *z.* pre-zygapophysis; *z'.* post-zygapophysis.

In the third cervical vertebra of *Ichthyornis*, however, we catch nature in the act, as it were, of forming a new type; by modifying one form of vertebra into another. Following this hint, the connection between these widely divergent types of structure soon becomes apparent; and the development of the modern style of avian vertebra from the fish-like, biconcave form finds a ready solution. In the anterior articulation of

this vertebra of *Ichthyornis* (figure 3), the surface looks downward and forward, being inclined at an angle of nearly 60° with the axis of the centrum. In vertical section, it is moderately convex, while transversely it is strongly concave; thus presenting a near approach to the saddle-like articulation. None of the other known vertebræ of *Ichthyornis* possess this character.

This highly specialized feature occurs at the first bend of the neck, and greatly facilitates motion in a vertical plane. If, now, we consider for a moment that the dominant motion in the neck of a modern bird is in a vertical plane, we see at once that anything that tends to facilitate this motion would be an advantage, and that the motion itself would tend directly to produce this modification. With biconcave vertebræ, the flexure in any direction is dependent on the elasticity of the fibrous tissue that connects them, as the edges of the cups do not slide over each other. An increasing movement in the neck of *Ichthyornis* in a vertical plane would tend to deflect the upper and lower margins of the circular cup, and to produce a vertical constriction, and at the same time to leave the lateral margins projecting; and this is precisely what we have in the third vertebra.

This modification of the vertebræ would naturally appear first where the neck had most motion, viz: in the anterior cervicals, and gradually would be extended down the neck; and, on to the sacrum, if the same flexure was continued.

Behind the axis, or where the vertical motion prevails, we find in modern birds no exception to the saddle articulation in the whole cervical series.

In the dorsal vertebræ, this cause would be less efficient, since the ribs and neural spines tend to restrict vertical motion, and hence to arrest this modification. This region, then, as might be expected, offers strong confirmatory evidence of the correctness of the above explanation; for here occur, among modern birds, the only true exceptions known in the presacral series to the characteristic saddle-shaped articulation. In *Strigops* and a few other land birds; in the Penguins, the Terns, and some other aquatic birds, one or more vertebræ in the dorsal region are without the saddle-shaped articulation, and are either opisthocœlian, or imperfectly biconcave. In such instances, we can usually, if not always, detect evidence of an arrest of vertical flexure. This may lock together the posterior dorsals by their neural spines, as in *Strigops*, leaving the power of lateral flexure: or several vertebræ may be coössified, as in *Accipiter* and some other *Raptores*, in which a stiff back is a positive advantage.

In the coössified sacral series of many birds, one or more of the anterior vertebræ have the saddle-shaped articulation. This, however, is no valid objection to the above explanation, since these vertebræ are really dorsals, and have evidently gradually coalesced with the true sacral vertebræ.

In the caudal vertebræ of recent birds we have, in a measure, the original biconcave structure preserved, for here the motion in every direction was much restricted. The caudal vertebræ of these birds, even in the most aberrant forms, are essentially the same, and in the fossil species the articulations at least appear to follow the general rule. In *Pavo* and *Geococcyx*, the caudal vertebræ exhibit a tendency to a procœlian union. Some other forms also show unimportant modifications of the normal type of caudal articulation, but nothing to suggest a real objection to the explanation now proposed of the origin of the vertebræ characteristic of Birds.

In bringing together the above facts, and others suggested by them, the classification and development of the various forms of vertebræ appear to be somewhat as follows:

(1.) *Biconcave vertebræ* (Fishes and Amphibians); the primitive type; a weak articulation, admitting free, but limited motion. From this form, have been directly derived the other varieties, namely:

(2.) *Plane vertebræ* (Mammals); affording a stronger joint, with motion still restricted.

(3.) *Cup-and-ball vertebræ* (Reptiles); a strong and flexible joint, well fitted for general motion, and evidently produced by it. The vertebræ are procœlian when lateral motion is dominant (Serpents); opisthocœlian with varied motion (Dinosaur cervicals).

(4.) *Saddle vertebræ* (Birds); the highest type; a very strong and free articulation, especially adapted to motion in a vertical plane, and mainly due originally to its predominance.

This subject will be more fully discussed and illustrated by the writer in a future communication.

Yale College, New Haven, Conn., Feb. 25th, 1879.

ART. XXXIII.—*Notice of Gaston de Saporta's Work: The Plants of the World before the Advent of Man*; by LEO LESQUEREUX.

COUNT SAPORTA'S new work entitled "Le Monde des Plantes avant l'apparition de l'Homme," is one of importance, not only for phyto-paleontologists and geologists, but for all who are interested in the history of our planet, in its physical laws, its gradual march of development, and its different phases until it became a fit habitation for the human race.

The first part of the book considers the birth or origin of life and the successive and progressive changes which have modified its forms. The phenomena relating to the existence of living creatures are examined in their applications to organisms from the lowest to the highest in degree of development.

The second chapter reviews the theory of evolution. The author calls it *transformism*. On this subject he rightly remarks, that the theory of evolution does not date from this century; that its origin and history are already old; that the system has been under the critical examination of great minds, who have rightly disparaged some of its extreme tendencies. I quote, in passing, some of the statements of the distinguished author, though they may appear disconnected, in order to show his mode of reasoning on the subject.

"Geology admits great divisions or distinct epochs, and successive formations. But when it comes to the determination of the precise limits of each, to the understanding of the number, the value, or the extent of the stages or subdivisions, the difficulties become inextricable; for generally between two epochs, there appear strata of mixed characters which forcibly excludes all idea of a marked separation between them."

With reference to the remains of plants, he says: "When the details of structure and of geographical distribution, which are recognized in a plant of our time, are in exact analogy with what is known of one or more fossil species of the same genus, it is legitimate to disregard some variations of detail, and to consider the more recent of the two species as a direct continuation of the other. To do otherwise would be to put aside all resources obtained from analogy and induction, or the method itself. Now accepting these premises we may say that there is no tree or shrub in Europe, in North America and in the Canary Islands, which is not found fossil under a specific form more or less intimately allied to one of our time. Nearly always a very ancient type is now represented in its decline, while the more recent appearance of a plant in geological time generally marks its wider extension now."

In the third chapter we have an exposition of the ancient

climates, and not merely that exposition which is indicated by paleontology, but an examination of the causes which have produced similarity of temperature over the whole globe during the first geological periods, and of those under the influence of which the zones of temperature became more and more distinct and narrowed. The discussion turns upon the value of the theories offered on the subject; the comparatively great density of the atmosphere overcharged with vapors, thus increasing its capacity for absorbing and preserving heat; the displacement of the axis of the planet; the internal heat of the globe, etc. All these hypothetical causes are recognized by the author as insufficient to account for the phenomenon. He closes the discussion in admitting as more probable the hypothesis of Blandet, supported by d'Archiac, based upon the nebular theory of Laplace, which refers the early temperature to the still excessive heat of the sun derived from the condensing nebula. After speaking of the sun as derived from the condensing nebula, he says: "This hypothesis may be far from giving a solution of all the facts; but it agrees well with the phenomena of the primitive world, and gives us such a clear reason for its climatic laws, the half veiled days of the Coal period with its transparent nights, the tepid temperature of the polar regions, the original extent of the torrid zones and their gradual subsequent contraction to the present limits, that one would be tempted to admit it, though still repeating in a whisper: Could this be the only cause of such a complex concurrence of phenomena?"*

The sentence here quoted closes the first part of the book; which is an introduction, preparing the way for the exposition of the character of what the author calls the vegetable periods of the primitive and secondary epochs.

In treating the subject, Saporta adopts the natural plan of considering the plants, so far as they are known by their remains, in their order of occurrence from the oldest formation to the more recent. The work follows without interruption the march of the vegetation, from its origin, so far as it has been observed, to the end of the Pliocene, and therefore offers multiplied points of comparison for ascertaining the progress of development of the vegetable types, the modification of their characters, the introduction or first appearance of new types, the destruction or disappearance of old ones, etc.

For Primordial, Paleozoic and Mesozoic times, the examination is limited to what is generally known.† The Primordial

* See on this subject an article of J. S. Gardner, in Nature, Dec. 12, 1878.

† Saporta divides the whole fossil vegetable world in four great epochs, the same as those recognized by Geology. 1. Primordial or Protozoic (Laurentian, Cambrian, Silurian); 2. Paleozoic (Devonian, Carboniferous, Permian); 3. Mesozoic (Triassic, Jurassic, Cretaceous), and 4. Neozoic for the Tertiary.

plants are merely Fucoids. The Silurian are marine species, especially. The author records as terrestrial plants those which have been described from the Cincinnati group. Their nature as representatives of a land vegetation is confirmed by the recent discovery of a splendid fern, *Eopteris Morieri* Sap., near the base of the Middle Silurian of France (the schists of Angiers, zone of the *Calymene Tristani*). This fine fern is placed as the frontispiece of the book—its right place indeed, for the fern, a pinna with large leaflets and perfectly distinct venation, resembles the Neuropterids of the Coal. It plainly proves that the land vegetation of the Middle Silurian, including already plants of so advanced types, must have been varied in its characters. Therefore, according to the law of evolution, it is evidence that a still more ancient land flora existed, probably contemporaneous with the first apparition of the vegetable marine forms.

The Devonian is mostly illustrated by species from Canada, some of which are figured, from Dawson, in Dana's Manual of Geology.

The Carboniferous has its illustrations from European plants, common types, also prevalent in the American Coal Measures.

The Permian flora is considered by Saporta as a mere continuation of that of the Carboniferous, the period being one of transition, as he says; though strictly, on the theory of transformism, all the periods are necessary periods of transition. The Permian has few distinct characters in its vegetation, some Conifers only, *Walchia*, *Ulmannia*, *Gingkophyllum*. This last type is already represented in the Permo-carboniferous of North America by *Saportea*, a sub-genus recently established by Fontaine and White, for the description of leaves very similar to those of the present *Gingko* of Japan.

In the Mesozoic (Mesophytic for the plants), the Trias has few typical forms, and these are merely Ferns and Conifers, whose generic relation, for this last group of plants at least, is with the Permian through *Voltzia* and *Albertia*. The Jurassic, *per contra*, whose flora is known to the author by extended researches, is illustrated in the work by numerous wood-cuts representing species published by himself, Heer, Brongniart and others, all from European specimens. The Jurassic floras of Spitzbergen and Siberia by Heer have afforded an important contribution. No species are mentioned from this country, where the Jurassic is not yet satisfactorily known by its plants. In this flora the *Cycadeæ*, *Protophyllum*, *Zamites* and *Protozamites*, are predominant, along with Ferns and Conifers of the Gingko type, *Baiera* and *Salisburia*.

For the Cretaceous the more important documents are taken from North America and Greenland. Europe has few Cretace-

ous deposits containing plants. In strata of a lower stage, near Beausset, France, remains of a species of fern and of an *Araucaria* have been found, with a fragment of dicotyledonous leaf referred by Saporta to *Magnolia.* The Bohemian Cenomanian has leaves of *Aralia*, *Hymenæa* and *Hedera*, of types recognized, by analogy of characters, in the flora of the Dakota group. From the Senonian of the Hartz are quoted *Abietites*, *Dryophyllum*, *Credneria*, the last two also typically represented in the Dakota group, which, considered by Saporta as referable to the Cenomanian, has five of its species represented as characteristic of the period in the wood-cuts of the work.

In closing the general consideration of the characters of the floras of the three preceding vegetable periods, the author remarks that the second or upper half of the Cretaceous may be viewed as marking by the appearance of dicotyledons the point of departure of the vegetation proper and peculiar to our zone, while the Coal period is that of the whole vegetable kingdom. "From the Cenomanian begins an evolution from which the new tribes progress by multiplication and variation in a constantly increasing proportion."

I shall now consider in more detail some of the points established in the examination of the Tertiary flora, the more important and original part of the book. For I find here a favorable occasion for comparing the essential characters of certain Tertiary groups of this continent, in order to determine thereby some points still in discussion as to their age.

Count Saporta divides the Tertiary into five vegetable periods: Paleocene, Eocene, Oligocene, Miocene and Pliocene. The Paleocene, which corresponds to the Suessonian of Orbigny, is separated from the more recent Cretaceous strata, the Maestricht chalk, by a gap whose width and duration are difficult to ascertain. This period is not yet well known, since the strata containing the vegetable remains of plants have been observed at few localities. To the Paleocene are referred the clay beds of Gelinden in Belgium, the tufaceous deposits of Sezanne in France, and the Suessonian sandstone (*Grès Soissonnais*). The flora of Gelinden is especially composed of species of *Quercineæ*, *Laurineæ*, *Viburnum*, *Hedera* (one species), some *Araliaceæ*, *Menispermeæ*, *Celastrineæ*, *Myrtaceæ*, etc., with some ferns, an *Osmunda* especially. Sezanne has a rich vegetation of large *Juglandeæ*, *Tiliaceæ*, with species of *Magnolia*, *Alnus*, *Salix*, *Virburnum*, *Cornus*, also some *Artocarpeæ*, *Meliaceæ*, *Pterospermeæ*, *Ficus*, *Symplocos* and a *Hedera* (a species of ivy scarcely distinct from the living Irish variety), and a grape. From the upper Paleocene strata have been obtained some *Myricaceæ* and *Araucariæ*, a *Bambusa*, and Palms with flabellate fronds.

In the examination of the remains of plants obtained from

the lower Lignitic strata of the Western territories, the essential characters of a number of species have been recognized as intimately related to, even identical with, those of some species of the flora of Sezanne, and from this referred to the Eocene. Count Saporta considers this question, on p. 221 of his book, as follows: "The Lignitic flora of a vast Tertiary formation of North America, rich in combustible mineral, which occupies an immense area in the new Territories in the West, Colorado, Utah, Wyoming, etc., is not yet sufficiently known. From the materials collected under the direction of the Geological Surveys of the United States, the plants appear referable to three different groups of the Tertiary, the lowest evidently corresponding to our Eocene. The relation of this group with the Paleocene of Europe is evident, notwithstanding the great geographical distance of the localities. This relation is manifested by the close affinity of some of the species of ferns with those of Gelinden and Sezanne, by the presence of Palms of similar characters in both countries, with *Artocarpeæ* and *Moreæ* which recall the *Protoficus* and *Artocarpoides* of Sezanne; species of *Cinnamomum* in the Lower Lignitic which have the facies of those of Gelinden. A *Viburnum*, *V. marginatum*, of Black Buttes, is scarcely distinguishable from the recently discovered *V. vitifolium* of Gelinden. It is the same with some other species; and these affinities are so near and so striking, that they force the idea of a connecting link not merely between the floras but between the regions, at the time when they had respectively the vegetation of which we now study the remains."

Considering merely the affinities mentioned above by the celebrated author, it would seem that the Lower Lignitic flora of this continent should be separated from the Eocene, and referred to the new subdivision established by him, the Paleocene. The flora of the Lower Lignitic, however, is distributed through a great thickness of the formations, and shows points of difference which should not be overlooked in comparing typical affinities, especially when the points of comparison are taken from two far distant countries on two different continents; and still more when the comparison relates to single groups of fossil plants, or vegetable remains obtained from a limited area, like that covered by the deposits of tufa at Sezanne. The lowest strata of the Lignitic at Point of Rocks has indeed a *Viburnum* intimately related, as remarked above by the author, to a species of the Paleocene of Gelinden. But it has also an *Ottelia* (tropical type), which is closely allied to another species of this genus, *O. Parisiensis*, of the Eocene of Paris (Trocadero). This local formation corresponds by its fruits, *Nipadites*, to that of the Sheppey beds of the Eocene of England. Along with *Sequoia longifolia*, which, according to Saporta, recalls a

Cretaceous type, the flora of Point of Rocks has also *Sequoia brevifolia* Heer, represented there by the largest proportion of the specimens. The same species is present in the Miocene flora of Greenland (Atanekerdluk) and also in that of the Baltic.* And still, in this small group of plants of Point of Rocks, twenty-seven, reduced to twenty species in eliminating those described from too poor specimens (as *Populus melanaria*), or those without marked geological affinity, we have *Ficus asarifolia* and *Ficus Dalmatica*, as positively identified so far as identity may be ascertained from fossil leaves, with two species of *d'Ettingshauena*. the first from Bilin, the second from Mount Promina, two localities now referred to the Oligocene (*Tongrian*); *Ficus iliæfolia*, a Miocene type, easily recognized, and found in the flora of the whole thickness of the Western Tertiary strata, even in the Pliocene of California; a *Diospyros;* a fine *Laurus;* a *Sabal* and a *Fucus*, all of recent types. A *Salvinia* also should be mentioned, as all the species of this genus have as yet been referred to the Miocene.

Yet it is not merely from the identification of a few plants that a relation between the floras of two epochs should be fixed or admitted, but from the general characters of the vegetation representing the climate, and from the general facies resulting from the progress of the vegetation, in passing from types admittedly inferior to others of a more advanced degree of perfection becoming more predominant. Considered in this way, the vegetation of the Lignitic, taken as a whole, indicates the action of a climate of an average temperature far above that of the Cretaceous Dakota Group, and still higher than that of the Paleocene, where the Oaks predominate and there are scarcely any Palms. The prodigious abundance of remains of Palms at Golden, at the Raton especially, is exactly comparable to that of the sandstone of La Sarthe (Upper Eocene), which, says Saporta, recall, by the beauty and the large size of their fronds, the Sabals of Cuba and Florida. If we cannot refer the whole Lignitic flora to that upper stage of the Eocene, if we find in it some typical affinities with the Paleocene, this results from the great thickness of the formation, which, in its four thousand feet of strata, may represent groups of floras related to two or more of the geological divisions established from separate groups of plants, like those which in Europe are referred to the Paleocene and the Eocene. This idea seems confirmed when we compare the diverse elements or groups of plants examined until now from the Lignitic. For if the Black Butte and Point of Rocks deposits are allied by the remains of *Viburnum* and *Ficus* of various species, those of Colorado and

* This Greenland flora, in the opinion of Saporta, Gardner, and other European authors, is closely related to the Eocene flora of Europe.

New Mexico near Trinidad are still more intimately related by a preponderance of Palms, of Ferns of true Eocene character, as recognized by Saporta and Gardner in the identification of Eocene species of England with some of those described from Golden; and also by the presence, at both localities, of *Sequoia* and *Abietites*, of Cretaceous affinity, and of large-leaved *Magnolias* and the *Rhamneæ* closely allied to those of Sezanne.

The Eocene period, as described in Saporta's work, has, at its base, deposits of the coarse limestone of Paris (*Calcaire grossier*) from which have been obtained the large fruits referred to the genus *Nipa* (*Nipadites*), an Indian type intermediate between *Pandaneæ* and the Palms, now inhabiting the flats along the borders of the Ganges. The same fruits, first found at Sheppey, have been discovered also at Paris in the same formation with the species of *Ottelia* mentioned above, along with a few leaves of small Palms, of *Nerium*, *Myrica* and *Zizyphus*.

Saporta has made long and systematic researches on the flora of the gypsum deposits of Aix, which are considered as referable, in their lower part at least, to the Eocene. His celebrated work (Les Etudes), on the vegetation of the Tertiary in the southwest of France, especially considers the fossil remains of that formation. They were discovered, in a very good state of preservation, along the borders of what was once an Eocene lake, whose duration was continued through the Oligocene to the lower Miocene, or Aquitanian. The general characters of this formation are remarkably similar to those of the Green River group of the Western Territories, and in the comparison of the flora also there are indeed some remarkable points of concordance. It is worth while to present in full and for future comparison the description given by Saporta of this group. He says: "This lake or its deposits were for a long time subjected to various changes by natural phenomena. Thermal springs, sometimes sulphurous, sometimes impregnated with carbonate of lime, affording emanations of mephitic gas, then later, volcanic eruptions, followed by flows of basalt, attest the subterranean action which extended even to the water, and brought, at different times, trouble and death to the inhabitants of the lake. Whole shoals of fishes were surprised and buried in the muddy clay of the bottom, a deposit which has faithfully preserved their remains. They are referable to many genera, one of which, *Lebias*, still inhabits fresh water in Sardinia and Northern Africa. Even insects were killed in immense numbers; small and scarcely perceptible flies, mosquitoes, butterflies, libellules, winged ants, bees, gave there to the winds their delicate remains, to be strewn along the shores and buried in the deposit that was soon to be hardened, some of the specimens still preserving traces of their col-

. During all this time the flowing water, springs and rivu- ;, uniting their action to that of the wind and rain, carried to : bottom of the lake fragments of plants of various kinds, ecially leaves, branches, flowers and fruits, indeed all the ·ts naturally torn from the trees and the shrubs growing in : neighborhood along the shore."

For those who have seen specimens of shale of the deposits Florissant in Colorado, thin laminæ covered with small frag- nts of plants (their branches, leaves, seeds, flowers, even or- ıs of reproduction, pistils and stamens), along with remains fishes and insects in immense number, even small feathers, : above description will seem as if dictated by an examina- n of the deposits of that locality. It applies equally well to ›se of the Green River station, Elko, the mouth of White ver, etc. It is right to remark, however, before looking to : relation in the characters of the plants, that the natural enomena which have caused the deposits of those remains, ve nothing abnormal, are not due to some cataclysm, but the result of natural atmospheric circumstances. The les in all the localities named above are in repeated lay- of two to five millimeters in thickness, mostly composed fine sandy materials, the thickest layers of the same na- e, but somewhat coarse, all covered upon the upper surface h the various remains mixed together. The thin layers, in eated superposition, represent therefore annual deposits of terials, mud deposits, laid down in the spring or in the rainy son, hardened in summer, and covered during the process of isolidation by insects, by small floating fragments of plants, , mixed with the mud and thrown up by their buoyancy to surface. The composition indicates a process of consolida- ı under the influence of heat or summer. Besides the pro- ious quantity of insects, the plants, mostly Conifers, are nchlets often deprived of their leaves, like those which, ing to the ground during the winter time, are carried away water in the spring. A large proportion of the cones are *Alnus*, and it is well known that these cones are persistent on the shrubs until the end of the spring. The leaves of ne species are extremely numerous, none of them crumpled, led or rolled, as if driven by currents, but flat, as if they had n imbedded in the muddy surface of the bottom when falling m the trees or shrubs along the border of a lake. In the ı beds of Green River, as they are called, the same phe- nenon is observed. One of the richest deposits, eight to ten t thick, is formed of alternate sandy layers three to five mil- eters thick, and it is between the layers that the fishes are nd petrified sometimes in prodigious numbers. This evi- ıtly shows that under the influence of summer heat, by

evaporation and gradual drainage, the area of the lakes or swamps being gradually diminished by shrinkage, the fishes were driven into deeper places, where finally enclosed they perished in masses. Their remains were later covered by the muddy water of the next overflow in the rainy season. In that immense formation of the Green River group, no trace of effects of volcanic agency is seen. It has been through its whole thickness a series of quiet, lacustrine deposits of calcareous clays, during an incalculable period of time. At Green River station, for example, from the bottom of the river to the top of the highest red buttes, about six hundred feet in thickness, the whole series is a succession of those laminated shales, varying only in their constituent beds, there being white calcareous clay, greenish, sandy, red ferruginous clay, in an uninterrupted succession of thin layers.

Considering the data furnished by the plants in reference to the synchronism of the Green River formation, it is only recently, or since the publication of the Tertiary flora, that we have obtained documents numerous and valuable enough for a future comparison. The collections made in the Green River group in 1847 and 1848, by the corps of the United States Geological Survey, and recently by the explorations under the direction of Princeton College, amount for specimens bearing remains of plants to at least ten thousand, mostly from Florissant. These plants have not yet been determined; part of them, those of the United States Survey only, have been superficially examined and separated in groups for definitive study. Of the whole number of plant remains, nearly one-half are leaves of *Planera*, apparently referable to three different species: *P. Ungeri*, *P. longifolia*, both equally predominant, and a less common one, with veins at a very acute angle of divergence and a facies different from that of the others. *P. Ungeri* is extremely abundant in the Miocene of Europe, especially in the upper strata. It is present in the Tertiary flora of *Greenland*, being found there in connection with or upon the same specimens with a *Pterospermites*, a *Hedera*, and *Sequoia Langsdorffi*. It is not quoted from Alaska and Spitzbergen. In the Gypseous beds of Aix one leaf only is mentioned of this species, from the fish beds of Bonnieux. The author says that it is very rare in this formation, but that it becomes more predominant in the flora of Manosque (Miocene). Fragments of Conifers, mostly Miocene types, *Taxodium*, *Glyptostrobus*, *Sequoia*, etc., abound at Florissant, with leaves of *Myrica*, referable to a dozen species at least, two of which are closely related to *M. Zacchariensis* and *M. arguta* of the Gypseous beds of Aix. At the same locality have been obtained numerous specimens of a *Populus*, which, though represented by leaves of various sizes and shapes, are

identifiable with P. *Heerii* Sap., of the beds of Aix, where it is very rare. The predominance of *Salvinia*, related to European Miocene types, is also marked in the Green River group, while one species only is described from the beds of Aix, there also very rare. We have also from Florissant a large specimen of a Sabal, which, like *Sabalites major* of the beds of Aix, seems related to the Miocene *Sabal major* of Europe.

If, therefore, we consider the relation of the flora of the Green River group to that of the Gypseous beds of Aix, merely from the number of identical species, it seems to be distant indeed, and more evidently marked with the Miocene. But then, there is against this conclusion the remarkable affinity in the dispersion and fragmentary state of the vegetable remains, and a similar facies of the flora apparent in the predominance of species of *Myrica* and other Southern types, like the leaves described as *Callicoma microphylla*, which, as remarked in the Tertiary Flora, cannot be referred to this Australian genus, but perhaps belong to some peculiar form of *Myrica*. We have also among the vegetable fragments of Florissant. *Diospyros*, *Catalpa*, *Fraxinus*, *Ailanthus*, *Paleocarya Engelhardtia*, *Ulmus*, *Acer*, mostly fruits and flowers, as mentioned by Saporta from the flora of Aix, leaves of peculiar forms of *Quercus*, referable to *Q. salicina* and *Q. antecedens* Sap., and flowers with long stamens, which, lacerated though they are, have some likeness to those of *Bombax*, all from the same flora of Aix.

But it is useless now to look to points of relation. Not only are the specimens from Florissant not yet positively determined, but the locality has, in the whole thickness of its shale, merely vegetable remains of plants growing around a shallow inlet of small area, that of a lake apparently, surrounded for a long period of time by the same kind of shrubs and trees, whose debris, annually strewn and preserved upon the muddy layer of the bottom, does not give a true representation of the general vegetation of the land. The American *Planera aquatica* inhabits only some river swamps of Florida and North Carolina. Its remains, if found in a fossil state, though they might be abundant in a peculiar locality, could not give us the slightest idea as to the facies of the land-flora of these regions. The great difference and variety in the characters of the plants found at other localities of the Green River group, in the deposits of Alkali station, of Elko, the mouth of White River and the cut-off of Green River, show how little we know as yet of the plants of the mighty group, which, like the Gypseous formation of Aix, may represent different geological periods at its lower and its upper parts.

Passing from the lower beds of Aix to the Oligocene (*Tongrian* for its upper part), Saporta sees in its flora the expo-

sition of a more equable and more generally humid climate. The essential types of vegetation recognized in Europe during this period are, for the Conifers, *Libocedrus salicornioides; Chamæcyparis* in two species; some *Sequoiæ*, among them *S. Tournalii* and *S. Coutsiæ; Taxodium distichum miocenicum*, and *Glyptostrobus Europœus*. With these Conifers the author mentions and figures species of *Comptonia*, some of them of typical affinity to the North American *C. asplenifolia*, others to Austro-Asiatic forms; oaks with coriaceous lobate leaves, a Palm, *Sabal major; Aralia Hercules*, species of *Myrica, Celastrus, Andromeda, Diospyros, Myrtus, Mimosa*, and, as related to present European types, *Betula, Carpinus, Ostrya, Ulmus, Acer*, already mentioned in the examination of the Gypseous formation of Aix. From this it is seen that, as the author remarks, this period is the transmission of an older to a new vegetable period. As to localities whose plants are referable to the Oligocene, the author quotes, for France, the deposits in Auvergne; those of Ronzon, of St. Zacharie and St. Jean de Garguier; the Gypseous beds of Gargas in Provence, of Alais, Armissan and Speeback; then Haering in Tyrol, Sotska in Styria, Sagor in Carinthia, and Mont Promina in Dalmatia. The floras of some of these localities were formerly referred either to the Miocene or to the Upper Eocene. The Flysch and Nummulite beds are Oligocene. From all these deposits eight to nine hundred species have been obtained.

The Miocene period is subdivided into two sections or subperiods. The lowest, the Aquitanian, begins with the regression of the Tongrian Sea, and terminates at the invasion of the Molassic, a period which ends with the more recent strata Miopliocene.

The Aquitanian has beds of lignite sometimes very thick. The more important localities where plants of this formation have been discovered are Manosque in Provence; Cadibona, Piedmont; Thorens, Savoy; Paudeze and Monod in Switzerland; Bovey Tracy in England; Coumi in Eubæa; Rhadoboy in Croatia, etc. The flora of both periods of the Miocene is well known, and has been so admirably well studied and described, especially by Heer, that every phytopaleontologist has become acquainted with its essential types. A large number of them are figured in Saporta's book.

The Oligocene types of Conifers, as also those of the dicotyledons, still remaining in the present flora, pass of course through the Miocene. But the climate of this period has a far less degree of uniformity, or the zones a less degree of expansion, and therefore the floras become more diversified, according to the latitude of the localities in which they are observed. Thus the flora of Coumi is marked by a large profusion of meri-

dional forms, though those of the temperate zone are not all excluded. In this flora appears the last European Cycad. Species of *Sabal* are present in all the groups of plants of the Aquitanian. The vegetation of the molasse is still more widely elucidated in the great tertiary flora of Heer. A number of species of *Populus*, *Planera Ungeri*, *Platanus aceroides*, *Liquidambar Europeum*, *Podogonium* species, *Ficus tiliæfolia*, *Myrica Œningensis*, *Comptonia acutiloba*, oaks belonging to the live oaks with semi-persistent leaves, and related to types of Mexico and Louisiana; species of *Tilia*, *Ulmus*, *Celtis*, *Magnolia*, *Liriodendron*, *Vitis*, are the predominant plants of the Upper Miocene period. They are most of them, if not all, recognized in the present vegetation of North America, to which that of the Miocene of Europe has been often compared.

The more important localities where remains of Upper Miocene plants have been discovered in Europe are Salzhausen, Rockenberg, etc., Weteravia; Gunzburg in Bavaria; Bilin in Bohemia; Manat and Mount Charray in France; Œningen in Switzerland; Parschlug and Gleichenberg in Styria; Tokay in Hungary; Vienna in Austria.

In the comparison of the American groups of Tertiary fossil plants, none has been found to agree with those of this period, by analogy of character, but that of Carbon or of the Washakie group, where essentially *Platanus aceroides* or *P. Guillielmæ*, and *Acer trilobatum*, abound, together with species described by Heer from the molasse of Switzerland. That peculiar *Ficus tiliæfolia*, considered as Miocene in Europe, easily recognized by its inequilateral leaves and the coarse and deep venation, abundant as it is in different localities of the Lower Lignitic, has also left its remains at Washakie. It is universally distributed in the ancient floras of this continent.

Saporta's book opens the examination of the Pliocene flora, by an interesting introduction. "The Miocene marks for Europe an era of vegetable splendor, an epoch of quiet temperature without extremes, of beneficial humidity, favoring the highest development of the vegetation upon a continent not yet feeling the change to which it was about to be subjected. The Pliocene period is the declining age of the European flora, the time when the climatic conditions are definitively altered, when the vegetation becomes gradually poor and ceases to gain anything. The progress of the phenomenon is slow, but it moves along an inclined plane on which it never stops. Those ornamental plants, those precious trees, those noble and elegant shrubs which are now carefully trained by artificial culture in European conservatories, were until then inhabitants, of Europe, but left it forever. One by one the ostracised plants take their departure, lingering here and there on the road to

exile. It is this exodus that we should have to describe if we could follow, step by step the march of retrogression, and indicate species by species, the progress and the result of this abandonment of our soil."

The decline in the richness of the vegetation of the Miocene period is described in detail by the author, and its causes are clearly exposed. He considers it (as remarked already) to be essentially the result of a gradual lowering of the temperature, which from its origin at the end of the Eocene, had been in constant progress until now, with casual modifications. It was due to the influence of a phenomenon which has acted upon the whole globe.

The vegetation of the Mio-pliocene has been rarely observed in Europe. From Sengaglia, Italy, Massalongo has described species of the genera *Greuia*, *Acer*, *Fagus*, most of them of present American types. The Conifers are still those of the Molasse, to which *Salisburia adiantoides* is added. *Sassafras*, *Liriodendron*, *Tilia*, *Cercis* are represented there also. Saporta has lately published the flora of the Pliocene tufa of Maximieux, with *Oreodaphne Heerii*, *Laurus Canariensis*, *Persea Caroliniensis*, *Acer opulifolium*, *Nerium oleander*, adding to the specific names the appellation *pliocenica*, all being mere varieties of species living now in the islands or African shores a few degrees south of France, or in the Gulf region of North America. There is also a *Buxus pliocenicus*, a *Torreya*, *Viburnum rugosum*, an *Ilex*, a *Juglans*, and among the ferns, *Woodwardia radicans* and *Adiantum reniforme*. As remarked by Saporta, the Poplar (*Populus alba pliocenica*), the Button Wood, *Platanus*, the Magnolia and the Tulip tree in the Mio-pliocene of Europe were about the same as the species now inhabiting North America; are specifically recognizable, though marked with slight differences. The relation of these species and others named by the author to some of the present time is examined by an exposition of the gradations which have given them their present characters.

The last chapter, entitled "a general insight into the ensemble of the period," cannot be summed up in a few sentences. It relates especially to the phenomena which have contributed, as causative agents or as elements, to the gradual modification of the vegetation from the end of the Mesozoic to the present times. A mass of facts are grouped, compared and discussed, in support of the conclusions, as evidence of the gradual development (evolution) under various local or general influences. As an exemplification of the march of transformism the author figures the leaves of three vegetable types, *Laurus*, *Hedera*, *Nerium*, as they appear in successive periods from the Eocene to the end of the Pliocene.

The remarks on this subject are rendered more interesting and conclusive by their correlative application to the animal kingdom. There is between the modifications of animal and vegetable types a remarkable coincidence which, however, is a matter of course, as animal life depends on the plants. It is well known, for example, that the Giraffe in its African wilderness especially feeds upon Acacia or Gum trees. This kind of plants appears first at the base of the Gypseous beds of Aix, at the end of the Eocene, and there also have been found the bones of Xiphodon, prototype of the Giraffe, which in its present form appears later in the Miocene in its migrating progress from France to Africa. It is at this epoch of the Upper Eocene that mammals make their first appearance in Europe, an advent prepared and predicted by the luxuriance of the vegetation of the Lower Eocene.

It should not be supposed from these cursory remarks, that Saporta's book, "Le Monde des Plantes," is a dry exposition of facts, or, descriptive enumeration of fossil remains, prepared only for the instruction of the paleontologist. Far from this; it is an exposition of the vegetation of our earth, in its gradual modifications from the oldest antiquity to our time, in a series of tableaux as clearly defined by words as they could be by the pencil of a painter. To these tableaux a multiplicity of facts,—some of them new and all instructive—give life and animation; while they are colored by the richness and brilliancy of an admirable style. The book is thus read without fatigue and with increasing interest, from the first page to the last.

Columbus, O., January 23, 1879.

Art. XXXIV.—*Double Stars discovered by Mr. Alvan G. Clark;* by S. W. Burnham.

The double stars discovered by Mr. Alvan G. Clark, of the well-known firm of Alvan Clark & Sons, telescope makers, Cambridgeport, Mass., are for the most part prominent and interesting objects, and, with the exception of Sirius, have not been published, or brought to the attention of astronomers generally. They are nearly all difficult pairs, and such as require for measurement a first-class, if not a large, instrument. All the recorded measures of each star in the following list are given, except of the first. Most of the micrometrical observations are by the Washington observers, and by Baron Dembowski and myself. All of the latter measures have been made at the Dearborn Observatory, Chicago.

The names and places of the stars are as follows:

No.	Star.	R. A. 1880.	Decl. 1880.	Magnitudes
1	Sirius.	$6^h\ 39^m\ 53^s$	−16° 33′	1 ..10
2	W VII, 1131.	7 40 20	+28 59	8 ..11
3	ρ Hydræ.	8 42 5	+ 6 17	5 ..13
4	L 23271.	12 20 37	+ 0 29	7½..10
5	46 Virginis.	12 54 25	− 2 43	5–6..8–9
6	Arg. (30) 2534.	14 28 45	+30 21	9½..10
7	ϵ Coronæ.	15 52 37	+27 14	4 ..13
8	102 Herculis.	18 3 38	+20 48	5 ..12–13
9	γ Lyræ.	18 54 27	+32 31	3 ..12
10	P XIX, 257.	19 39 15	+10 29	7½.. 7½
11	ζ Sagittæ.	19 43 39	+18 51	6 .. 6
12	α^2 Capricorni.	20 11 24	−12 55	3 ..
13	τ Cygni.	21 10 0	+37 32	5½.. 8
14	78 Pegasi.	23 37 57	+28 42.	5 .. 8

No. 1. *Sirius.*

The history of this interesting system is too well known to require more than a brief mention. From periodical irregularities in the observed proper motion of Sirius, Bessel, more than thirty years ago, suspected the existence of a satellite revolving with the large star around their common center of gravity. The theoretical orbit of the disturbing body was calculated by Peters, and a period of fifty years found to satisfy the meridian observations. The suspected companion was looked for by many observers without success. In January, 1862, Mr. Clark placed the 18½-inch object glass, now at the Dearborn Observatory, Chicago, then the largest object glass in the world, in a temporary stand, and turned it upon Sirius. A small star was at once detected almost exactly in the place assigned by theory. Once discovered, it was readily seen and measured with the same instruments with which it had been vainly looked for before. I have seen it repeatedly with my 6-inch Clark refractor; but a steady air is necessary with any moderate aperture, because of the great brilliancy of Sirius, which overpowers the light of the small star, and because of its low altitude in northern latitudes. Probably in the southern hemisphere a good 5-inch object glass would show it satisfactorily. Why it should have remained so long undiscovered, after attention had been called to it, cannot be easily explained. For this discovery, Mr. Clark was awarded the Lalande gold medal.

The companion has been measured every year since 1862, and during the latter portion of the time the observations are very numerous. The last orbit of the theoretical satellite, computed by Auwers, based upon all the available observations of proper motion, gives a period of 49·40 years. From these elements an ephemeris has been calculated for every second or

third year, which is given in the following table, together with some of the actual measures made near the corresponding times. It will be seen that the angular motion of the real star is more rapid than that of the theoretical star, and with a less change in distance, indicating a longer period than fifty years.

Calculated.			Observed.			
1862·0	85°·4	10″·10	1862·2	84°·6	10″·7	Bond.
			62·2	85·0	10·09	Rutherfurd.
			63·2	82·5	10·15	O. Struve.
1865·0	79·9	10·78	1865·2	77·2	10·60	O. Struve.
			65·2	76·8	10·77	Förster.
			65·2	75·0	10·07	Secchi.
1868·0	75·0	11·15	1868·2	70·2	11·25	Vogel.
			68·2	69·5	11·35	Bruhns.
			68·3	71·6	10·95	Engelmann.
			69·2	68·6	11·26	Dunér.
1871·0	70·3	11·20	1871·2	64·0	11·21	Dunér.
			72·2	59·8	11·14	Dunér.
			72·2	67·7	11·55	Newcomb.
1874·0	65·5	10·95	1873·2	65·8	11·12	Hall.
			73·2	60·9	10·65	Dunér.
			73·9	59·4	12·27	Hall.
			74·2	59·0	11·46	Newcomb.
			74·2	58·7	10·99	Holden.
			74·2	57·9	11·10	Hall.
			75·2	57·1	10·81	Dunér.
			75·2	56·6	11·41	Newcomb.
			75·2	56·3	11·08	Hall.
1876·0	62·1	10·59	1876·1	54·9	11·82	Holden.
			76·2	55·2	11·19	Hall.
			77·1	53·1	11·20	Stone.
			77·2	52·8	11·35	Holden.
			77·3	53·4	10·95	Hall.
1878·0	58·4	10·05	78·0	52·4	10·83	Burnham.
			78·1	50·5	11·07	Holden.
			78·2	51·7	10·76	Hall.
			79·1	50·7	10·44	Burnham.
1880·0	54·2	9·33				

The last observed position is the mean result of ten nights' measures made at the Dearborn Observatory in the past two months.

The existence of another satellite has been suggested as an explanation of the variation shown above, but all attempts to find any other body have thus far been unsuccessful.

No. 2.

Discovered in May, 1876, with the 12-inch object glass now at the Vienna Observatory. This very unequal pair is in the neighborhood of Pollux, about 40′ south, and a little following. The only measure is the following:

Burnham.....P=114°·9 D=0″·81 1879·0 1*n*

No. 3. *ρ Hydræ.*

The very minute attendant to this star was detected with the Washington 26-inch refractor. The only measures I am acquainted with are those made with the 18½-inch of the Dearborn Observatory. A mean of three observations is as follows:

Burnham	P=144°·9	D=12″·40	1878·0	3*n*

No. 4. L 23271.

A close and unequal pair discovered May 19, 1876, with the Vienna 12-inch object glass. The following are all the measures:

Hall	P=233°·6	D=0″·85	1876·4	3*n*
Dembowski ..	234·1	0·87	1877·4	2*n*

No. 5. 46 *Virginis.*

Discovered on the same evening as the preceding, and with the same glass. It is a fine pair, and just within the reach of a 6-inch aperture. It has been measured as follows:

Hall	P=158°·9	D=1″·32	1876·4	3*n*
Dembowski ..	148·5	1·21	1877·4	2*n*
Stone	145·7	1·15	1878·2	1*n*
Burnham	151·5	1·48	1878·3	2*n*

The magnitude of the small star is rated 8 by Dembowski, 9·5 by Stone, and 11 by Hall.

In measuring this pair, a very faint companion, about 13th magnitude, was detected.

P=116°·9 D=33″·86 1878·3

No. 6.

A difficult pair of small stars in a low-power field with *σ* Bootis, *np.* It has been measured by Dembowski only, and the following is a mean of two observations:

Dembowski ...	P=139°·8	D=0″·76	1877·0	2*n*

This was also found with the Vienna glass.

No. 7. *ε Coronæ.*

A very difficult and unequal pair discovered May, 1876, with the Washington 26-inch. The companion is an exceedingly minute point of light, even with a large aperture. Mr. Edgecomb, of Hartford, sees it with a 9·4-inch Clark refractor, but this must be regarded as a very remarkable test of acute vision. The following are all the measures:

Hall	P=351°·4	D=2″·17	1876·4	4*n*
Burnham	360·2	1·86	1878·3	2*n*

No. 8. 102 *Herculis.*

A faint companion detected with the 12-inch Clark object glass now in the possession of Dr. Draper. The only measure is:

Burnham	P=46°·9	D=23″·42	1878·4	1*n*

No. 9. *γ Lyræ.* (*O*Σ 544.)

This pair, discovered a number of years since with the 12-inch glass now at the Vienna Observatory, is one of the recently published additions to the Pulkowa Catalogue. It has been measured as follows:

Otto Struve..	P=296°·9	D=13″·79	1868·6	3*n*
Newcomb....	297·8	12·48	1874·5	1–4*n*
Burnham	301·1	12·76	1878·4	2*n*

No. 10. P XIX, 257. (AC=Σ2570=Ḧ I. 91=S 723.)

This has been known as a wide pair nearly a century. With the Draper 12-inch, the large star in August, 1875, was found to be an excessively close pair. I have measured this with Dearborn Observatory refractor on four nights, as follows:

P=126°·1	....	1877·68
147·4	....	1877·72
147·0	D=0″·26	1878·62
142·0	0·32	1878·70

There is no evidence of change in the 9·5 magnitude star, as will appear from the following observations:

Herschel I...........	P=278°·2	....	1783·6	1*n*
Struve	276·2	D=4″·08	1827·0	3*n*
Mitchel	275·7	3·95	1847·7	1*n*
Secchi	275·3	4·10	1857·6	1*n*
Wilson and Seabroke.	279·9	3·87	1874·1	2*n*
Wilson and Seabroke.	277·8	4·30	1876·7	1*n*
Burnham	276·6	4·16	1878·7	1*n*

No. 11. *ζ Sagittæ.* (AC=Σ2585=Ḧ II. 30=S*h* 307.)

Discovered as a wide pair in 1781 by Herschel I. It was measured by many observers down to 1875, when the duplicity of the principal star was detected with the same instrument with which the two preceding discoveries were made. My measures of this at the Dearborn Observatory indicate an increase in the distance. I found it obviously less difficult in 1878 than the previous year. The individual measures are as follows:

P=158°·3	D=0″·22	1877·72
157·6	0·24	1877·73
158·1	0·27	1877·77
158·7	0·35	1878·64
155·4	0·35	1878·70

Struve gives the magnitutes, 5·7 and 8·7, of the wide pair. These stars appear to be relatively fixed.

Struve	P=312°·8	D=8°·49	1831·1	7*n*
O. Struve	311·2	8·71	1846·9	7*n*
Wrottesley	311·8	8·77	1854·6	3*n*
Wilson and Seabroke.	311·2	8·8	1873·6	1*n*

No. 12. α^2 *Capricorni.* (AB=H 608.)

Herschel II discovered a 16-magnitude companion to this star and entered it in his second catalogue of double stars. Since that time it has received but little attention from double-star observers. Under favorable conditions a 6-inch refractor will show it fairly. The following are all the measures:

Herschel II	P=141°·2	D=6″ ±	1830±	1*n*
Mitchel	144·1	6·36	1846·7	13*n*
Holden	146·2	....	1874·6	2*n*
Burnham...........	150·2	7·41	1878·5	3*n*

In November, 1862, with the 18½-inch object glass now at the Dearborn Observatory, Mr. Clark found that this minute companion was itself a close, equal pair. Professor Young was able to see it with the 9·4-inch refractor of the Dartmouth College Observatory when observing at Sherman, Colorado, from an altitude of more than 8,000 feet above the sea level. This, to anyone who has seen this minute pair, is a striking illustration of the importance of getting above the lower atmosphere. The following are all the measures:

Holden	P=57°·6	D=1″·72	1874·6	1*n*
Newcomb	58·6	1·24	1874·6	1*n*
Hall	65·2	1·14	1875·7	1*n*
Hall	63·2	....	1876·7	1*n*
Burnham...........	61·2	1·06	1878·5	2*n*

No. 13. τ *Cygni.*

This fine pair was discovered in October, 1874, with the 26-inch object glass manufactured for Mr. L. J. McCormick of Chicago. It has already shown rapid angular motion, and is undoubtedly a binary system. It has been carefully and regularly observed by Baron Dembowski. The individual measures are as follows:

P=174·8	D=1·06	1874·90
174·3	1·43	1875·33
171·0	1·33	1875·51
171·5	1·37	1875·67
168·9	1·26	1875·89
163·2	1·26	1876·76
159·8	1·23	1876·82
157·0	1·47	1877·39
157·7	1·25	1877·43
157·5	1·33	1877·59
155·8	1·37	1877·70
155·0	1·21	1877·79
152·5	1·15	1877·84
154·2	1·14	1877·92
152·9	1·17	1877·94

Other measures, with the mean results of Dembowski's observations, are:

Newcomb	P=162°·6	D=1″·10	1874·8	2*n*
Dembowski	174·5	1·24	1875·1	3*n*
Dembowski	170·5	1·32	1875·7	2*n*
Dembowski	161·5	1·24	1876·8	2*n*
Waldo	166·9	1·62	1876·9	2*n*
Hall	160·2	1·03	1776·9	2*n*
Dembowski	155·3	1·26	1877·7	8*n*
Burnham	150·0	1·06	1878·4	1*n*

There is a third extremely faint star:

Newcomb	P=261°·7	D=15″·10	1874·7	1*n*
Hall	260·3	15·68	1876·9	1*n*

No. 14. 78 *Pegasi.*

An unequal, but not very difficult pair, discovered in Nov., 1875, with the 12-inch glass now at the Morrison Observatory, Glasgow, Missouri. Dembowski gives its magnitudes: 5·0 yellow, 8·1 olive. The only measures are:

Dembowski	P=192°·0	D=1″·45	1876·6	4*n*
Burnham	190·8	1·54	1878·8	1*n*

Chicago, March 1, 1879.

ART. XXXV.—*Underground Temperatures on the Comstock Lode;* by JOHN A. CHURCH, Professor of Mining, Ohio State University, Columbus, Ohio.

DURING the summer and fall of 1877, I was engaged in making an extended examination of the mines situated on the Comstock lode in Nevada.* Though investigations of the kind described in this paper were but a subordinate part of the proposed work, and the time given to them necessarily restricted, enough facts were accumulated to show on how vast a scale the heat phenomena of the district are exhibited.

The Comstock mines are not only the only hot ones of note in this country but they appear to be the hottest in the world. The highest mine temperature reported to the British Coal Committee was 106° F., but some of the Cornish mines have shown an air temperature of 100° to 113° F. There the air was hotter than the rock, which is never the case on the Comstock. The hottest water reported in a Welsh mine had a temperature of 125° F. (J. A. Phillips). All of these observations are surpassed by the extraordinary conditions of the Comstock.

*This examination was made in connection with the United States Survey of the Territories west of the 100th meridian, in charge of Lieut. Geo. M. Wheeler, Corps of Engineers, U. S. A.

The rock in the lower levels (1900–2000 feet) of the Comstock mines appears to have a pretty uniform temperature of 130° F. This was the reading obtained for me on several occasions by Mr. Comstock, foreman of the Ophir mine, and about the same temperature was found by Mr. Perrin, foreman of the Chollar Potosi, by Mr. Cosgrove, foreman of the Yellow Jacket (139½° F. and 136° F., 2200 foot level), and by myself in the Crown Point and other mines. These readings were obtained by placing a thermometer in a drill-hole immediately after the hole was finished, and leaving it there for periods varying from ten minutes to half an hour.

The holes in which the thermometers were placed were not sunk especially for this work of testing, but were the ordinary drill-holes made for the purpose of blasting the rock. They varied therefore from about ten inches to three feet in depth, but their shallowness by no means indicates that the results obtained are vitiated by alteration of the conditions through exposure to radiation.

Mining on the Comstock proceeds with extraordinary rapidity. The drifts are advanced steadily at the rate of three, five, and sometimes even eight and ten feet a day, and therefore the ground in which the miners are working is always fresh ground. The drill-hole which is made to-day was covered a week ago by thirty to fifty feet of rock. Very often the holes were in ground which had been exposed only one or two hours, having been sunk immediately after a blast which threw off four or five feet of the rock. The surface which was thus thrown down itself had not been exposed more than twenty-four hours. The high temperature and small flow of air in the heading forbid the supposition that any sensible diminution of heat could have taken place at the bottom of a drill-hole made in material of such low conductivity as rock. These facts give the results as much value as if they had been obtained from holes twenty feet deep.

The surface of the rock exposed to the air of the drift was found on one occasion to be about 123° F., the experiment being made near the "header" or end of the drift. The air itself was found to show considerable uniformity when its temperature was taken under circumstances that were at all similar. In freshly opened ground it varied from 108° to 116° F., and higher temperatures are reported at various points, reaching in fact as high as 123° F. in the 1900 level of the Gould & Curry.

The temperature of the air is subject to more fluctuations than that of the rock, for the simple reason that it is artificially supplied to the mine, and varies according to the distance to which it is carried, the quantity, velocity in the pipe, its initial temperature, and moisture in the drift. The most important

causes of variation are the length of the drift and the presence or absence of water. In general the variation at similar depths is not more than eight degrees. Drifts that do not exceed two or three hundred feet in length are *usually* not above 110° or 112° F. in temperature and often they are below this. But when the length increases to 1200 and 1500 feet the temperature may rise to 116° F. without any other change in the circumstances. But much higher temperatures are encountered in places where the increase cannot be attributed to artificial causes.

These limits are, however, not in the least degree true of the water which enters the drifts from the country rock, and also from the lode rocks. That approaches more nearly 150° F. The vast body of water which has filled the Savage and Hale & Norcross mines for two years, and from which it is safe to say a million tons of water have been pumped within twelve months, gave me a temperature of 154° F. Even after being pumped to the surface through an iron pipe exposed, in the shaft of the Hale & Norcross, to a descending current of fresh air for more than a thousand feet, and then flowing for one or two hundred feet through an open sluice in a drain-tunnel which discharges into a measuring-box, the water in this box was found to have a temperature of no less than 145° F.

But the water varies in temperature in different parts of the lode like the rock and the air. In the East crosscut 2000 foot level, of the Crown Point Mine, which is noted for its extreme heat, a small stream of water, after flowing for nearly one hundred and fifty feet over the bottom of the drift, was found to have a temperature of 157° F. Here the drift was closed so that the water was but little exposed to evaporation. On the contrary, in other places the water is much less hot, but I believe it is always hotter than the air, and in many cases it appears to be hotter than the rock is found to be, except in especially hot spots.

These places of exceptionally high temperature are very numerous throughout the lode and they appear to occupy narrow belts. The East crosscut of the Crown Point 2000 feet level, which was temporarily abandoned and boarded up on account of the heat, gave me an *air* temperature of 150° F., the thermometer being thrust through a crack in the boarding. I felt convinced that at the head of this crosscut the heat must be higher than this, and Mr. Balch, foreman of the mine, informed me that it had been proved so. Another hot spot is in the Imperial Consolidated Mine. Here the Black Dike splits, sending a shoot off to the northeast, and a drift has been run on the two thousand foot level, along the eastern side of this branch dyke. This proved to be a very hot spot indeed. Rock, air and water were all so much above the usual limits of

temperature even in these hot mines that the work of cutting the drift must have been extremely severe. It might not have been accomplished had not the expedient been adopted of boarding or "lagging" up the sides of the drift with a double thickness of plank, breaking joints. This confined the water, which poured down the walls, to a tight chamber, and left the main part of the drift for the men to work in comparative comfort. The lagging remains, and has been carried around into the main drift, which is still in active use. Its joints are calked with tow, and, one of these being stripped for me, the steam from the water immediately poured out and proved to be scalding-hot when tested by the finger. I did not, however, succeed in getting a fair reading of the thermometer, because the crack was too small to admit more than the end of the bulb. The thermometer must have cooled by the evaporation of condensed moisture from its bulb; but, even under these adverse circumstances, the temperature of the steam was taken at 123°.

The Belcher south incline has a hot belt of rock, quite narrow, a short distance above the 1900 station, and in fact similar hot places are found in most of the mines.

It is noticeable that the neighborhood of a dike is apt to be hotter than other portions of the rock. This is the case in the Julia, and in the Imperial, the branch dike is hot, as just mentioned, and the main incline, which is quite near the Black Dike has always been noted for its extreme heat. But nearness to the Black Dike is also a characteristic of most inclined shafts on the lode. Some are west of it; some in it for long distances; others east of it. These inclines do not all exhibit unusual heat and it will be shown farther on that there is a special cause for the exceptions.

Belts of excessively hot ground are not the only noticeable phenomena in these mines. More remarkable still are the belts of unusually *cold* rock. These are fewer in number than the hot belts, but they are also strongly marked. They are always wet, and the water that drips through the crevices of the shattered rock that composes them is noticeably cold to the touch, and cools down the air of the drift. Such a wet, cold belt of rock exists on the eight hundred foot level of the Justice Mine, and there is a very decided change of temperature in passing from one side of it to the other. Lest the low temperature of this spot should be attributed to the water which drains through it from the surface, it is well to add that water drips from the rock in numerous places in these as in most mines, and that usually it is hot, or at least warm.

Other cold belts are found in the mines which are not so cool as that in the Justice, but are perceptibly cooler than the rock at a short distance from them. They complete a well-

linked chain of heat phenomena, extending from rocks that are sensibly cold to the touch, and may not have a temperature above 50° or 60° F., through rocks that have the average atmospheric temperature, and those which are as hot as surface rocks ever become in Nevada, to those which have a temperature of 157° F. There is no reason to doubt that the gradation is quite regular, and the transition from the lower to the higher temperature is made through a much larger series of intermediate steps than the accidental thermometer readings taken show.

The rock is usually dry. Wet portions exist, but these are disposed in comparatively narrow bands parallel with the lode and separated by thick masses of rock; the lode is usually perfectly dry, and never exhibits more than the average leakage of mines. Wet rock is the exception, and dry rock the rule, through the whole lode. In the drifts cut through this hot, dry rock, the walls of the freshly exposed surfaces are painful to the hand, and the air is often filled with dust. The rock is both hard and tough, but, in spite of its strength, it gives an impression of fine porosity to the touch, due probably to its trachytic character. It often has the odor of clay, but not always. It may be slightly adherent, or the impression of dryness upon the tongue may be due to its heat.

The plan of the Yellow Jacket mine is simple and such as to eliminate complications from the single problem of heat absorption by moving currents of air from rock surfaces. From the 1,531 level two parallel winzes are sunk on the lode, inclining with it. They are four hundred and thirteen feet apart, and connected on every lower level by the main north and south drift. The Yellow Jacket is a downcast mine, and the air current passes down the vertical shaft to the 1,119-foot level, thence down the incline to the 1,531 level, through a drift to the south winze, and thence down this winze to the 2,200 level, the bottom of the mine. On its way from the 1,531 it sends a current through the 1,732, 1,935 and 2,040 levels, these currents being reunited in the north winze, which is the upcast. The north winze does not reach to the surface, and no air rises "to day" in the mine, the entire current flowing into the Imperial and Bullion mines, both north of the Yellow Jacket, and both of them exclusively upcast.

Captain Taylor has placed Fahrenheit thermometers of the common kind, with japanned tin cases, at the surface, foot of the vertical shaft (1,119 level), 1,732 south and north winzes, 1,935 north winze, and 2,040 south and north winzes. The south winze is downcast, and the thermometers placed here on the different levels measure the increase of heat in the winze itself, while those which are hung at the north winze measure

the increase of heat, which each "split" of air gains in moving through 413 feet of drift, that being the distance between the winzes. This fortunate arrangement of the ventilating currents presents the most favorable opportunity I have ever observed for studying the problems involved. The thermometers should be replaced with standard instruments, and the air current measured twice a week for a year, in each drift. The result would be the best series of observations obtainable, probably in any American mine, for the comparative shortness of the paths followed by the air, when contrasted with the long drifts of some coal mines, is compensated for by the high temperature of the rocks, and the marked increase of heat in the air. It is also extremely rare to find the conditions of heat absorption so little complicated by artificial additions.

The air-current entering the mine July 2d, 1877, was measured and found to be 18,140 cubic feet. On the 1732 level the "split" or secondary air-current was found to contain 7200 cubic feet, and for the purpose of illustrating the steady flow of heat from the rock, we may reasonably assume that 18,000 cubic feet of air enter the mine every minute, and that this current is divided into three splits of 6000 cubic feet each, which pass from the south winze 413 feet to the north winze, on each of the three levels, 1732, 1935, and 2040. The second of these is out of consideration, from the fact that there is only one thermometer on it, so that no comparison of the initial and final temperatures can be made.

The following tables contain a summary of all the observations which I have been able to obtain. The record is imperfect on account of the destruction of some tally boards, and this has compelled me to omit some records that are preserved, because the corresponding observations in the same drift are wanting. Where the omission takes place, the figures are included in brackets. The figures given are monthly averages, and the final averages refer only to numbers not in brackets.

Only the observations on the 1732 and 2040 foot levels will be made use of, as these are the only ones where a horizontal air current has its temperature measured at two points in its path. Omitting November from the period of the 1700 foot level and December from that of the 2040 foot level, we have for the average of nine months' observations a difference of temperature between the south and north winzes amounting to

1732 foot level	(89·39° – 78·06°)	11·33° F.
2040 " "	(92·30° – 85·35°)	6·95° F.

This difference represents the heat which the air current has absorbed in passing a distance of 413 feet on these levels. In my report made to Lieutenant Wheeler, and also in a paper on this subject presented to the American Institute of Mining

Engineers, these quantities are given as 10·56° F. and 7·87° F., the difference being due to the fact that they were the average of seven instead of nine months' observations.

Yellow Jacket Mine.—Morning Temperature, 6 A. M.

	Surface.	1119 feet.	1782 feet. S. Winze.	1782 feet. N. Winze.	1900 feet. N. Winze.	2040. S. Winze.	2040. N. Winze.
December, 1876,....		59·27°	80·23°	92·99°			
January, 1877,....		52·55	73·42	86·90		85·35°	93·22°
February, "		49·75	76·99	83·71		86·59	93·99
March, "		53·81	78·13	89·20	90·29°	83·68	94·99
April, "		49·87	77·40	88·13	89·97	85·90	93·77
May, "	(44·48°)	53·77	83·42	90·45	90·99	83·39	93·61
June, "	56·07	57·40	79·39	91·47	93·27	88·26	93·63
July, "			(84·00)		94·07		
August, "			(83·23)		94·50		
September, "	56·67	60·80	81·86	91·67	96·60	88·37	92·13
October, "	46·10	55·13	73·65	90·44	92·07	83·23	88·36
November, "	39·90		(76·53)		88·50	81·27	87·23
December, "	35·84						
January, 1878,....	33·39						
February, "	33·93						
March, "	39·84						
April, "	42·37						
May, "	51·10						
Average,...........	43·52	54·71	78·28	89·48	92·25	85·11	92·33
Time taken, ...	10 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.

Yellow Jacket Mine.—Evening Temperatures, 6 P. M.

	Surface.	1119 feet.	1782 feet. S. Winze.	1782 feet. N. Winze.	1932 feet. N. Winze.	2040 feet. S. Winze.	2040 feet. N. Winze.
December, 1876,....		59·20°	80·84°	90·92°			
January, 1877,....		50·77	77·82	86·10		83·23°	93·36°
February, "			76·71	84·03		86·82	93·43
March, "		55·52	74·07	88·58	90·29°	86·68	95·00
April, "		52·83	77·57	88·33	89·93	85·87	93·80
May, "	70·47°	61·50	79·42	91·77	93·03	87·16	93·48
June, "	70·33	61·50	79·40	91·77	93·03	88·20	93·73
July, "			(84·16)		94·29		
August, "			(83·42)		94·29		
September, "	69·13	62·76	81·82	91·11	96·67	87·90	92·00
October, "	54·55	57·30	72·99	91·00	92·10	83·32	88·58
November, "	45·43		(77·40)		89·50	81·13	87·23
December, "	39·58						
January, 1878,....	38·84						
February, "	37·61						
March, "	44·87						
April, "	52·37						
May, "	60·77						
Average,...........	53·09	57·67	77·85	89·30	92·57	85·60	92·28
Time taken,........	11 mo's.	8 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.
Average, morning and evening, ...	48·30	56·19	78·06	89·39	92·41	85·35	92·30

The 1732 level affords us the best evidence that the incessant drain of heat cannot be maintained by supply from a store accumulated in the rock. This drift was probably completed by January 1, 1876, or perhaps some months earlier. It has been constantly in use as an air way, but after this long exposure no diminution in its heating power has been noticed. It has lost the intense heat it had when first opened, but remains at an average temperature of about 90° F.

In other respects I have not observed any circumstances which throw serious doubt upon the thermometer readings. The instruments are not standards, it is true, but they are properly hung on timbers, and usually with ten or twelve inches of wood or air between them and the rock surface. Whenever compared with one of the survey thermometers, hung in the center of the moving air-current, they have not shown a variation of more than one degree. The daily readings are quite uniform, the fluctuations of more than one degree not exceeding twenty-three in a series of about 360 observations. The highest fluctuation noticed is three degrees.

ART. XXXVI.—*United States Geological Survey of the Fortieth Parallel.* Vol. I. *Systematic Geology;* by CLARENCE KING. Reviewed by RAPHAEL PUMPELLY.

THE February number of this Journal contained, in the form of citations, a summary of the results of the Fortieth Parallel Survey in the department of Stratigraphical Geology. The object of the present paper is to present a general review of the more noteworthy results and generalizations, in the other departments.

Quaternary Period.—The Quaternary period of the Cordilleras was contemporaneous with the Glacial and Drift period of the East and of Europe. Its record differs, however, in that no continental glacier ever invaded the Cordillera region to leave, after melting, its immense load of ground-moraine. The climatic conditions which caused the extension of the Scandinavian ice-cap over Northern Europe and of the Greenland ice-cap over Northeastern America produced indeed vast systems of glaciers in the Cordilleras, but they were Alpine ice-streams and as such were localized around the numerous lofty condensing centers and accompanied by the phenomena peculiar to this form of glaciers.

At the east the floods of the Champlain epoch, proceeding from the melting ice, covered the gently graded surface with detritus from the ground-moraine; but the rapid fall of the

Cordillera streams permitted the Glacial floods to form torrents which, aided by the suspended material, cut deep cañons and spread the debris in enormous quantities over the margins of the plains at the mouths of the mountain valleys. An immense amount of erosion was accomplished during the Glacial epoch and there is evidence, to be given below, that it was done during two periods of glacier extension in the Quaternary; during the first and greater the floods cut the deep V-shaped cañons, and during the second the glaciers transformed the upper part of these into U-shaped cañons, and we may add that the second floods deepened the V cañons below the foot of the glacier.

The Great Plains are underlaid by beds which were deposited in a great fresh-water lake. In the southeast these beds dip under the Gulf of Mexico, while near the Rocky Mountains they are 7,000 feet above the Ocean. It is therefore evident that they have been tilted, for otherwise we should have to suppose that there existed a lake whose surface was 7,000 feet above the sea, and for which there was no eastern enclosing wall. Both General G. K. Warren and Mr. King have shown that after the Pliocene such a tilting really took place, so that during Quaternary time this declivity had, as now, free drainage to the Ocean, and was traversed by the rivers flooded from the glaciers.

In the Great Basin the Pliocene—Shoshone—lake was disturbed but not drained off. Its eastern and western edges were depressed 1,500 to 2,000 feet, producing two basins which were occupied by two Quaternary lakes. The eastern one (of which Great Salt Lake is the remnant), extending over 2½ degrees of longitude and 3 degrees of latitude, has been named Lake Bonneville, by Mr. G. K. Gilbert. The western body of water, called by King, Lake Lahontan, occupied about the same absolute range in latitude, with about the same width.

Mr. King infers that the Pliocene lakes were nearly or quite dried up before the Quaternary, because: 1, while the beds contain remnants of only a purely fresh-water fauna, the upper strata sometimes contain deposits of alkaline sulphates and chlorides, that could form in a fresh-water sea only after a nearly complete evaporation; 2, the oldest Quaternary deposits on the sides of the extinct lake basins are subaerial gravels, which were swept by hill-wash and river-floods far out from the parent mountains. During their prime, these inland fresh-water seas were filled to their outlets, Lake Bonneville, over 1,000 feet deep, drained through Red Rock Pass into the Snake and Columbia Rivers. The outlet of Lake Lahontan may have been southward, and the lake must have been over 500 feet deep.

From the fact that the sediments of these lakes are underlaid and overlaid by subaerial gravels, both King and Gilbert infer that there was a very wet period between two dry periods. But our author goes much further, and from the results of a study of the chemistry of the waters, as expressed in the soluble contents of the remaining lakes, and in the natural evaporation products, constructs an ingenious and it would seem a well-founded hypothetical climatic history of the Quaternary period. The argument may be briefly outlined. The now dry shores of the ancient Lake Lahontan are in many places covered, sometimes twenty to sixty feet deep, with a tufaceous deposit, which is often distinctly crystallized and then shows the very characteristic forms of gaylussite—a hydrated carbonate of soda and lime. But chemical analyses show that the soda and water are gone, and that the mineral is now calcite—only the external form being that of gaylussite. In short, we have here an instance of pseudomorphism on a large scale. This pseudomorphous material King calls *Thinolite.* Near Ragtown, Nevada, in a lake which is one of the remnants of Lahontan, and which is presumably fed by springs, the forming of gaylussite can now be seen in operation. It is a dense water very rich in soda carbonate, and when the lake shrinks during the dry season, gaylussite crystals are deposited on the beach and on floating organic substances. Both the facts at this lake and Fritsche's experiments show that gaylussite can form only in the presence of a large excess of carbonate of soda. When the saline water of this lake is diluted during the wet season, the gaylussite is dissolved again.

The thinolite tufa occurs up to an altitude of 470 feet above Pyramid Lake, or within thirty feet of the highest known level of the extinct Lahontan Lake. The inference from this is that the lake must have been long exposed, without an outlet, to concentration by evaporation, and perhaps by contributions from alkaline springs, in order to deposit gaylussite at such an altitude; and, in order to have formed the vast deposits of tufa —originally gaylussite—the lake must have almost wholly evaporated. Now the evaporation of a sea, which, with a depth of 470 feet, was sufficiently saline to deposit gaylussite, would leave its residuary lakes in the condition of saturated solutions; but the fact is that the larger relics of Lahontan, viz: Pyramid and Winnemucca Lakes are sufficiently fresh to support numerous fishes, including one or two of the *Salmonidæ.* It is evident, therefore, that the residuary water of the evaporation of Lahontan, that produced these tufas, must have wholly disappeared. This could only take place by the basin filling to its outlet and remaining at that altitude long enough for its dissolved salts to drain off and for the water to become

thoroughly freshened, after which a rapid evaporation brought about the present condition of things.

This argument places before us what seems unimpeachable evidence of the existence of two periods of great humidity and three of desiccation. These several periods King correlates as follows: the first dry period was at the close of the Pliocene; the two wet periods correspond to the two phases of maximum extension of the glaciers and were contemporaneous with the great ice epoch and the Reindeer ice epoch of Europe; the intermediate dry period corresponds with Newberry's Forest-bed horizon; and the last dry period still continues.

During the intermediate dry time there was probably less vegetation even than now in the Cordilleras and on the Great Plains, and it was probably then, that the greater portion of the lœss of the Missouri and Mississippi valleys was transported to its present position by the west winds as the present writer has shown elsewhere.

The well known fact that the surface of Great Salt Lake is rising—it has risen 11 feet since 1867—has been generally ascribed to the cultivation of the surrounding region. Mr. King shows this to be a wrong inference, for a similar increase has affected all the lakes of the Great Basin. He shows partly from observations connected with the growth of trees on the Sierra, that this is due to a climatic oscillation that began about 1860 and which was the first of its kind and extent that has occurred within at least 250 years. This question of oscillation of climate is full of importance to the populations that are pouring into the regions of the Great Plains during the present moist extreme.

Origin of crystalline schists and granite.—Some space is devoted in this volume to the presentation of original hypotheses explaining the origin of crystalline schists and granitic rocks, of fusion in the interior of the globe, and the cause of varieties in volcanic rocks and the law of succession in eruptions.

Mr. King sees in the crystalline schists beds of sedimentary material in which the change that has taken place has been confined to a re-arrangement of the constituents and the obliteration of the interstitial spaces between the detrital particles. Thus purely silicious beds remain as quartzites, lime beds as marble, and mixed sediments as the various compound crystalline schists. The sediments were penetrated with the original saline solutions of the sea and the metamorphism was effected under great pressure and moderate heat but in the absence of fusion. This is proved by the total absence of the microscopic glass-particles that all volcanic rocks show, and by the abundance of cavities containing fluids and salts that the microscope reveals in almost all metamorphic rocks. There was no fusion,

although it is possible that the temperature of fusion existed but was prevented by the counteracting pressure from producing liquefaction. The hypothesis is summarized thus:

Conditions of metamorphism.—1. There is a horizon below the surface, at a depth which increases with the secular cooling of the globe, at which the heat and pressure are sufficient to produce the chemical activity needed to effect metamorphism. 2. This horizon sinks deeper with the secular cooling. 3. So long as this horizon is within the depth to which sediments are brought down by displacement of the crust and subsidence, so long will crystalline schists be produced. 4. When by secular cooling the horizon of requisite temperature shall have sunk below the possible levels to which sediments can be depressed, then forever afterward the formation of crystalline schists is ended in that segment of the crust.

Out of gneisses thus formed, Mr. King derives the structureless granitic rocks by the action of tangential pressure. During the horizontal compression due to the shrinkage of the globe, there acts also gravitation. Now when the tangential was slight compared with the down-pressing action of gravitation the schists were simply corrugated; but when the tangential was largely in excess, then the structure of the schists was destroyed and the constituent minerals were to a great extent broken up. This is supposed to account for the granitic rocks and all the transitional forms between these and the corresponding gneissoidal varieties.

Genesis and Classification of volcanic rocks.—In regard to the origin of volcanic rocks, Mr. King argues as follows: The temperature of the earth increases from the surface downward; and owing to the rapid conduction in the outer part of the crust, the rate of increase is very rapid at first and then very slow. Pressure also increases from the surface downward, but, owing to the increase in density, the rate of increase is smallest near the surface and more rapid in depth. Now the action of pressure is directly antagonistic to fusion—increase of pressure raising the melting point. It is therefore evident that a comparison of the strength of these two forces—for and against fusion—will show that the resistance offered by pressure to fusion will be least at the point of maximum rate of increase of temperature, and that from that point down the more rapid rate of increase of pressure than of temperature, renders fusion more and more impossible. The position of this point, or *couche*, in which pressure offers least resistance to fusion must be near the surface. The observed rate of increase would indicate that at a depth of about fifty miles the temperature would produce fusion of rock if not prevented by the pressure. Now if by removal of the superincumbent material

the pressure on any given point is diminished at a more rapid rate than that of the cooling of the *couches* below, and if this removal of pressure proceed far enough, fusion must take place; and, being localized, it will form subterranean lakes of molten rock. This *couche* of possible fusion, like all the isothermal and isobaric *couches*, must be parallel to the surface and must rise in ridge-form under mountain ranges. And it is in the active erosion that takes place in mountains that Mr. King finds the means of diminishing the pressure. One of the first objections, that would be advanced to this, would be that erosion does not act with sufficient rapidity. But our author would probably point, and with reason, to the vast accumulations of detrital sediment—thousands of feet thick and covering hundreds or thousands of square miles—which have formed during single geological epochs. During the Cretaceous there accumulated from one to one and one-half miles in thickness of detrital sediment which probably occupies now a larger area than that from which it was eroded, and the following Eocene and Miocene epochs witnessed the enormous outpourings of lava.

In these subterranean lakes of fused rock, are differentiated the varieties of volcanic rocks. Baron Richthofen, after a critical study of volcanic products in Europe, Asia, California and Nevada, proposed a classification of them into propylite, andesite, trachyte, rhyolite and basalt, and stated that wherever several of them occurred in one district the chronological order of their eruption was that in which we have named them. This generalization has been amply corroborated by the 40th Parallel Survey and extended. For Mr. King finds that there is a sufficient persistence of occurrence among the sub-varieties to justify the subdivision of each of Richthofen's "orders" into an acid, a mean and a basic variety (or species) as, for instance, quartz-propylite, hornblende-propylite, augite-propylite, quartz-trachyte, mica-trachyte, augite-trachyte, etc. He goes further, and brings rhyolite and basalt together as the acid and basic extremes of a new order, "neolite."

Now the observations of his survey show that there is a regular order of succession in the eruption of sub-varieties: that when all the varieties of an order appear, the mean was ejected first, then the acid, and last of all the basic. This sequence is explained thus: Fusion, being a function of erosion, is ephemeral, the duration of fluidity being limited by the sinking of the isotherms. Each molten lake must therefore pass through a series of phases which may be stated as follows: 1st, fusion; 2d, crystallization of constituent minerals; 3d, separation, by specific gravity, into a basic, lower *couche* and an acid, upper *couche;* 4th, re-solidification by the reëstablish-

ment of the ante-fusion relation between pressure and temperature.

Now if eruption takes place before the separation, the lava will have a mean composition: as separation takes place the uppermost, or acid, layer is ejected; finally the acid *couche* cools first on account of its higher melting point and higher position, and eruption at this period forces up the basic lava from the *couche*. This is the sequence for King's subdivisions of the different genera; the observed sequence of the genera themselves, i. e. of Richthofen's orders, he explains by supposing them—if we understand him rightly—to represent, from propylite to neolite, each a lower horizon, the depths being determined by the time-intervals; and the differences in character and mean constitution being expressions of the varying of the conditions at increasing depths.

The argument of which this sketch gives only the salient points is undoubtedly, in the writer's opinion, the most consistent hypothesis—the nearest approach to a satisfactory theory—that has been thus far advanced to explain the complicated system of related phenomena under consideration.

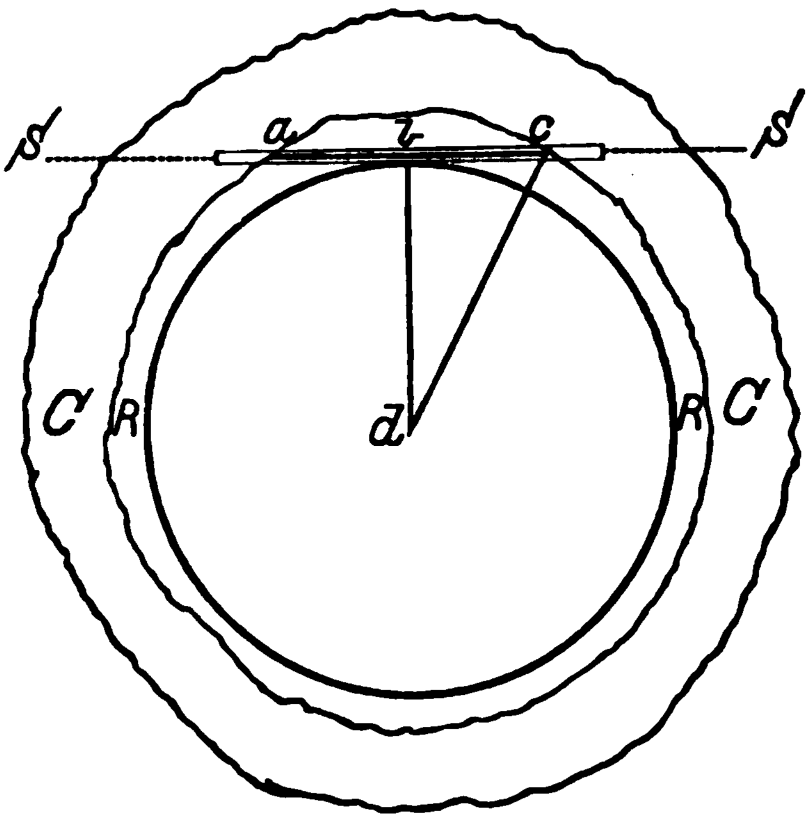
Mountain-building.—In the last chapter there is a review of the conspicuous disturbances of the crust, showing that from the Laurentian to the Quaternary there have been, within the area of the Survey, thirteen periods of mountain-building activity. "In this complicated history . . . . have occurred both upheaval and subsidence as related to the sea-level; plication, always greatest at the western edge of the disturbed area: the formation of folds forty thousand feet from summit to base; the development of faults with at least forty thousand feet of dislocation; the tilting of horizontal regions into broad inclined planes without disturbance, and the division, by complicated fault-systems, of wide areas into numerous separate blocks, of which some are depressed below the level of their adjacent companion blocks." "It is also a general law that those regions which experience elevation without local disturbance are the regions of relatively thin sediment superposed on a comparatively unaccidented Archæan foundation, whereas those which suffer the extremest plication are covered by the thickest deposits overlying and adjacent to the greatest Archaean Mountain ranges." The instances of paroxysmal depression are found to have affected areas immediately after the removal from them of immense thicknesses of material: while the instances of gradual depression occur over areas that were being very heavily loaded with sediment.

ART. XXXVII.—*On a Method of Estimating the Thickness of Young's Reversing Layer*; by W. H. PULSIFER.

A PART of my duties, as a member of the Fort Worth Eclipse party, consisted of the spectroscopic observation of the contacts. I used a telespectroscope combining a four-inch Clark telescope of four feet ten inches focal length, and a ten-prism Browning solar spectroscope. The field included the lines between W. L. 6600 and 6300.

At second contact I observed the reversal of the Fraunhofer lines, and was surprised to find the reversed lines shortened at each end, and occupying but about one-third of the width of the spectrum, while the C line was not shortened and remained in view after the other lines had disappeared. At the moment no explanation of the phenomenon presented itself, but afterward it occurred to me that it was occasioned by the extension of the slit of my spectroscope beyond the reversion layer on each side, and that a measurement of the image of the sun formed on the slit, and of the length of the slit itself, would enable me to estimate the thickness of the reversing layer. Careful measurement showed the diameter of the sun's image on the slit to be $0{\cdot}54^{in.}$, and the length of the slit $0{\cdot}08^{in.}$.

In the diagram, C represents the chromosphere, R the reversing layer, S the slit, *a b c* the shortened lines, and *d b* the



radius of the sun. The difference in the length of the lines *d b* and *d c* represents the minimum thickness of the layer, as indicated by the reversed lines observed. Assuming the sun's diameter to be 860,000 miles, and accepting the measurement of the sun's image and of the slit, and the statement that the reversed lines occupied but one-third of the width of the spectrum, the difference in the length of the lines *d b* and *d c* is found to be 524 miles.

ART. XXXVIII.—*The Lower Jaw of Loxolophodon*;* by HENRY F. OSBORN and FRANCIS SPEIR, Jr. With a Plate.

LITTLE has been known hitherto of the real character of the lower jaw of Loxolophodon, a genus which together with Uintatherium forms at present the Sub-order Dinocerata. To the literature which has appeared upon the lower jaw of the Dinocerata, Professor Marsh has contributed in this Journal (III, vol. xi, page 163), a description of a specimen of *Uintatherium* (*Dinoceras*) *laticeps* lacking only the canine-incisor series, and it is safe to say that the general characters of this jaw are also applicable to all the known species of Uintatherium; Professor Cope (Proc. Am. Phil. Soc., Feb. 21, 1873) has given a partial description of the lower jaw of Loxolophodon from fragments which were wanting in the most essential features, leaving a wide gap in our knowledge of this important genus.

The following description is based upon specimens collected in the South Bitter Creek country of Wyoming, about fifteen miles south of Laclede, a station on the old overland road. The horizon is considered by King, Cope and Hayden as belonging to the Bridger Series, which here overlies conformably the Vermillion Creek group. The material comprises two jaws, the first found with a large canine-tusk belongs, without doubt, to *L. cornutus*; the second is smaller, possibly of a female of the same species; together they give basis for a complete study, save of the coronoid process which is lost in both. The accompanying plate figures the former specimen, the incisor-canine series have been placed in position from the latter specimen, in which the alveoli are preserved.

General character of the jaw.—One of the most surprising features of the Dinocerata is the disparity existing between the size and strength of the lower jaw, and the large and formidable head. This is even more marked in Loxolophodon than in Uintatherium, for in general contour the lower jaw is neither long nor deep. In *L. cornutus*. the species in hand, it extends from the well-advanced glenoid cavity barely to the tips of the slender premaxillaries, where it is wholly overhung by the broad and projecting nasals, giving it at once an undersized appearance. The rami are shallow and of equal depth throughout; forward they are wholly in the vertical plane, but behind the molar series they diverge considerably below. The angle of the ramus is not prominent; nearly in a vertical line above this is the condyle. The symphysis is long and narrow. The

* This article is the first of the second series of Paleontological Bulletins upon the Eocene fauna of Wyoming, to be issued from the E. M. Museum of Princeton College.

downward processes below the canine-molar diastema are not strongly marked. The molar series are nearly parallel.

Detailed description.—The ramus swells for the coronoid process close to the lower border, and immediately in front of the rise is the nearly straight molar series. The coronoid rises well up into the temporal fossa, judging from its great thickness below. Slightly above the plane of the molar series are the condyles; they are small, decidedly convex, directed backward and slightly upward with their transverse axes converging. Below these the posterior border narrows and is concave, thickening again into the rough rounded angle which projects slightly back of the condyles. The smooth lower border is nearly straight from the angle to below the first premolar, arching but slightly downward; here it both broadens and deepens and interiorly forms a slightly concave surface extending toward the symphysis, exteriorly it has a process homologous to the pendant process in Uintatherium. This arches gently downward and outward, at an angle probably coincident with the projection of the superior canines; when the jaws are in position it falls not half an inch below the deepest portion of the rami. The downward processes in Loxolophodon are then by no means a distinctive feature of the jaw; on the contrary when compared with *U.* (*D.*) *laticeps*, or when placed side by side with the robust process of the lower jaw of *U. Leidianum* in the E. M. Museum, they show a disparity in size, that seems unaccountable in genera so closely allied.

The dental foramen is large and is situated on a line with the molar series. The mental foramen is double and placed just beneath the canine.

At the chin we find the most peculiar modification of the jaw. The processes, as seen from below, have a more outward than downward direction, forming at the posterior half of the symphysis a broad, slightly concave floor, about six inches in width; below the lateral incisor they disappear, and the chin narrows into a prow-shaped keel. The inner margin of the canine-incisor alveolus is well raised, giving the series the appearance of being placed on the side of the jaw. The alveolus is highest at the canine, and dips downward in front; this would throw the teeth greatly out of the horizontal line, were it not that the dental series increase rapidly in size forward. The teeth are arranged not in a semicircle, but in converging lines two and a half inches apart at the canine and in contact at the median incisor; thus the chin is contracted towards its extremity above as well as below. Between the dental series in front and the high thin borders of the diastema behind is the deeply concave floor of the mouth.

Measurements of the lower jaw.

	M.
Extreme length from infra-condylar depression to symphysis	·295
Depth at last molar	·08
Internal depth of jaw at posterior edge of symphysis	·071
Thickness of jaw at angle	·014
" " at first premolar	·036

The molar series (fig. 2) display three transverse crests, the anterior the most prominent, and forming with the second an open angle, with the apex directed inward; the posterior crest less prominent than the other two, is serrate throughout the series. A cingulum, faint elsewhere, is quite strongly developed at the edges of the third crest. Just beyond the inner apex of the middle crest is a large accessory tubercle which is constant on the true molars and last premolar inclusive.

Beginning the detailed description with the last molar, for it has the characters of all the others in strongest development, we find it is by far the largest of the series. The posterior crest attains its greatest elevation at the center. The middle crest marks two valleys, an anterior and a posterior; the latter dips from a central elevation, corresponding to the highest part of the posterior crest, to the cingulum on either side. Of the two valleys the anterior, which slopes from the apex strongly outward, is narrower but deeper. The anterior crest is nearly horizontal, concave on its forward surface, terminating interiorly in a prominent and exteriorly in a lesser tubercle.

The second molar presents the same characters as the last, but is greatly reduced in size; this disparity is more marked here than it is between any two of the other teeth. The first molar is so much more worn that it fixes three as the number of true molars without doubt.

In the premolar series the anterior crest is relatively more prominent and its terminal tubercles become equal in size. The posterior crest extends more on the inner side of the crown. The third is the only one of the premolars on which the tubercle beyond the apex is found. The second and third premolars have the middle crest comparatively lower, while in the first it rises to form a continuous course with the anterior, giving a crescentic appearance to this portion of the tooth, accompanied by a considerable elevation of the outer marginal tubercle.

The canine incisor series.—Owing to the fragmentary state of the mandible of Loxolophodon found by Professor Cope in the Mammoth Butte beds he was led astray as to the lower incisors. In his pamphlet, "On the Short-Footed Ungulata," (Proc. Am. Phil. Soc., Feb. 21, 1873,) he inferred that "the lower incisors must be regarded as wanting. This is in conformity with the structure of the upper jaw and is rendered probable by the great

reduction of the symphysis of the lower jaw in this species." Professor Marsh subsequently found the specimen of *U.* (*D.*) *laticeps*, already referred to. In this specimen the alveoli for six lower incisors were found, but the teeth themselves were unfortunately wanting; nevertheless the correct dental formula for the Sub-order was established.

The canines and incisors in *L. cornutus* are contiguous and directed upward and forward at such an angle that the two lobes, larger and smaller, are on a line and divide the attrition. They are placed not in a semicircle but in straight converging lines. They decrease in size regularly backward.

The median incisor (fig. 3) consists of an outer convex and inner flat surface. The outer portion is divided by a median valley into two convex lobes; of these, the anterior is placed higher upon the fang, is much the larger and comes to a pointed apex; a section below the apex would be plano-convex, the plane surface being interior. The median valley, dividing the two lobes externally, rises from the cingulum and is cleft near the top by a slight elevation which is possibly homologous to the median crest of the molar series. The posterior lobe is flatter externally, rises lower upon the fang and comes to an obtuse point about two-thirds the height of the anterior. The inner surface of the tooth is nearly flat, with a slightly raised margin; this throughout, except at the apices of the two lobes, is faintly serrate, and is notched at the summit of the median valley. The second incisor (fig. 4) is shorter and more obtuse than the first but larger than the lateral incisor or canine; in it the notches that mark the upper margin are less distinct; opposite the outer convexities the inner surfaces are more concave. In the lateral incisor (fig. 5) the median valley is deeper and the anterior cleft is less marked, while at the head of the valley the upper margin arches inward; the posterior lobe is relatively higher. In the canine the cleft at the head of the valley has disappeared and consequently there is a deep single valley; opposed to this is a more pronounced convexity of the inner surface. The fangs throughout the series are long, stout, arch forward slightly, and decrease in size with the crowns.

Measurements of the Teeth.

	M.
Entire length of molar series,	·165
Length of true molar series,	·094
Fore and aft diameter of last true molar,	·047
Transverse diameter of same,	·036
Height of crown of same,	·030
Fore and aft diameter of first premolar,	·023
Transverse diameter of same,	·019
Height of crown of same,	·022
Length of canine-incisor series,	·140

Measurements of the Teeth.

	M.
Width of median incisor,	·016
Length of same,	·041
Height of crown of same,	·037
Width of external lobe of same,	·026
Width of internal lobe of same,	·015
Length of fang of same,	·060
Width of canine,	·015
Length of same,	·036
Length of fang of same,	·053

The entire dental series show distinctly two types of structure; the molars are modelled after the last true molar which is the most specialized of the series; while the median incisor is the pattern for the canine-incisor series.

Having now detailed the structural peculiarities of the lower jaw there remains to be shown the important bearing that it has in its general form upon many of the still unsettled questions concerning the habits and type-modification of the Loxolophodon and allied genera. The undersized downward processes are of value in so far as they fully confirm Loxolophodon as independent genus from Uintatherium; they also show that the robust processes of Uintatherium did not have for their object the protection of the upper tusks; otherwise they throw no new light upon the subject at issue. It is around the canine-incisor series that our interest chiefly centers. Immediately the question arises how did these teeth, worn at their tips, strongly directed forward and fixed with stout fangs, meet the upper jaw and how were they of use in feeding. This it seems to us, finds a ready answer when we turn our attention to the premaxillary bones; of these Professor Cope (Proc. Am. Phil. Soc., Feb. 21st, 1873) says: "the premaxillaries do not enclose the very large foramen incisivum in front and are therefore deeply furcate." A careful examination of a fine specimen in the Princeton Museum does not wholly confirm this statement, if we understand it aright. In the posterior half, the premaxillaries are united by a bony plate, and as the inner margin of the anterior half is not a rough line indicating muscular attachment but an irregularly broken edge, it is reasonable to infer that between these bones there was a thin plate of true cartilage in which ossification was certainly advancing at the sides if it never reached the center. These edentulous premaxillaries probably supported a callous pad; if so it is singular that this modification so characteristic of the Ruminants should be found in this formidable aberrant type, especially as it has strong perissodactyle affinities. Now as regards the process of feeding, it is certain that, setting aside the short neck and elevated shoulders, the extreme protrusion of the nasals would not per-

mit of the action of close cropping, and this leaves the only alternative that the animal browsed from the tall reeds and undergrowth which accompanied a moist and tropical climate. These conjectures, if established by more extended research, are valuable in connection with the dispute regarding the proboscidean characters of the sub-order, which occupied many pages in vol. vii of the American Naturalist, for they do away with the necessity for a proboscis, pointing rather to a powerful prehensile upper lip. It will be understood, however, that no more validity is claimed for them than that of mere hypothesis, to be strengthened or broken down by further evidence.

Explanation of plate.—Fig. 1, left lower ramus of *L. cornutus*. Fig. 2, molar series of same. Fig. 3, median incisor. Fig. 4, second incisor. Fig. 5, lateral incisor. Fig. 6, canine. The ramus is drawn one-third natural size; the remaining figures are two-thirds natural size.

ART. XXXIX.—*Notice of recent Additions to the Marine Fauna of the eastern coast of North America, No. 4*; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLI.

IN the following notice there will be found descriptions of new species of Hydroids, belonging to the *Plumularidæ*, referred to in the preceding number, but from which they were omitted, for lack of space. These and other species herein named, as well as those described in the last number, form part of the extensive collections of marine Invertebrata, belonging to the U. S. Commission of Fish and Fisheries, which have been entrusted to me for examination and description, by the Commissioner, Professor S. F. Baird. In the present notice, there are also included certain species which were collected during several special dredging expeditions, undertaken by the author, with Professor S. I. Smith and others, in 1864, 1865, 1868, 1870, previous to the organization of the Fish Commission.

HYDROIDA.

Cladocarpus Pourtalesii, sp. nov.

A large species, forming a tall, unbranched, secund plume. Hydrocaulus stout, compound, rough; the component tubes run in an irregular subspiral course, and each bears two rows of nematothecæ. The pinnæ are very numerous, about an inch long, and arise alternately, in one line, along the front of the stem and curve outward and upward. Hydrothecæ about twice as long as broad, only slightly enlarged toward the aperture, which has a smooth even margin; intrathecal septum

conspicuous, the free edge curled upward. Lateral nematothecæ short, broad, rising but slightly above the margin of the hydrothecæ; median nematothecæ short, adnate, except close to the end, rather more than one-third as long as the hydrothecæ. The gonothecæ, which are borne on short, jointed, branches arising from the base of the pinnæ, are subcalceoliform, when seen in a side-view, but in a front-view obovate, narrowing to a slender base; aperture lunate, near the end, on one side, the lower lip sunken or incurved. There are one to five gonothecæ on each supporting branch. Color, light yellowish.

Height of largest specimen, 200^{mm}; length of naked part of stem, 40^{mm}; length of pinnæ, 18 to 22^{mm}; diameter of stem, 1·5^{mm}.

S. W from Cape Sable, N. S., 112–115 fathoms, gravel, 1877, U. S. F. Com. Also taken on Banquereau, N. S., in 300 fathoms, by the crew of the schooner "Magic," Capt. W. Thompson.

Cladocarpus cornutus, sp. nov.

Hydroid subpinnately branched, rather rigid, with compound stem. The few branches (four in one example) diverge at a wide angle, and are like the main stem. Pinnæ not crowded, spreading outward abruptly, and somewhat bent backward, about a third of an inch long. Hydrothecæ large, somewhat compressed, adnate to the stem, somewhat triangular or obconic in a side view, expanding from base to rim, with a conspicuous median keel or ridge along the front, which rises into a prominent, lanceolate, acute lobe projecting considerably beyond the lateral borders, which are divided into about five, often unequal, obtuse, subangular lobes, a small incurved lobe being situated each side of the base of the large median lobe; intrathecal septum narrow, situated near the bottom of the hydrothecæ. Lateral nematothecæ elongated, the ends free, spreading outward laterally, margin crenulated; median nematothecæ short, narrow, tapering, directed outward, with the mouth very oblique, and margin crenulated, free for about half their length, and not extending so far as the middle of the hydrotheca. Each joint of the pinnæ is divided internally into five or six compartments by transverse septa. Gonothecæ swollen, obovate, borne on the mid-rib of the main stem and principal branches, at the bases of short, jointed, special protective branchlets, either simple or forked, many of which have a single hydrotheca, of the ordinary form, on the last joint, but only nematothecæ on the others. Dark horn-color.

Height, 70^{mm}; length of longest branch, 20^{mm}; length of longest pinnæ, 8 to 9^{mm}.

Off Sable Island, N. S., on Banquereau, in about 200 fathoms. Obtained by the crew of the schooner "Marion," Capt. J. W. Collins, Sept. 12, 1878, and preserved by Mr. Newcomb.

Cladocarpus speciosus, sp. nov.

Our single specimen is small, unbranched, without gonophores. Stem compound. Pinnæ slender, not crowded, spreading at a wide angle. Hydrothecæ rather short, slightly campanulate, in a side view the breadth of the aperture is equal to two-thirds the depth; a faint median ridge on the front; the margin is divided rather regularly into about eleven or thirteen, moderate sized, subacute teeth, the outer median tooth, and that next to it, on each side, a little longer than the rest; intrathecal septum well-developed, near the bottom; lateral nematothecæ short, swollen in the middle, narrowed to the aperture, margin crenulated; median nematothecæ short, adnate, except at the end, where the oblique aperture faces the hydrotheca, margin crenulated.

Height, 26^{mm}; length of pinnæ, 10^{mm}.

Banquereau, off Sable Island, N. S., in about 200 fathoms, with the preceding species.

MOLLUSCA.

Cingula Jan-Mayeni nob.

Rissoa Jan-Mayeni Friele, Nyt Mag. for Naturvidensk., 1877, Jan-Mayen Mollusca, (author's copies, p. 4, figs. 4 a, b.)

Several specimens of this species were sent to me by Mr. J. F. Whiteaves, who dredged them in 1873, in the Gulf of St. Lawrence, 200 fathoms, mud. It is recorded as from 70 to 300 fathoms, off Greenland, by Friele. It is allied to *C. arenaria* Migh. (=*R. scrobiculatata* Möll.) and to *C. carinata* Mighels, but is a larger and stouter species than either of these, with stronger sculpture and more angular and shouldered whorls. The color is dark chestnut-brown. There are, in our specimens, four strong revolving ridges on the last whorl; the upper one nodulous; the lowest, stout, basal; about fourteen transverse subsutural costæ, extend to and join the first revolving ridge, giving rise to the small tubercles. On the spire only two spiral lines are visible. Length, 4^{mm}; breadth, $2{\cdot}5^{mm}$.

Cingula areolata nob.

Turritella areolata Stimp., Shells of New England, p. 35, 1851.

This species, which has long been lost sight of, and even omitted from Binney's Gould, I have recently rediscovered among small shells dredged at Mt. Desert Island, coast of Maine, about 1860, by the late Professor Wm. C. Cleveland, and also among the shells from the Gulf of St. Lawrence, sent by Mr. J. F. Whiteaves, who dredged it in ninety-six fathoms, in Trinity Bay. It is allied to *C. carinata* Mighels, but is a more delicate, longer, and more pointed shell, translucent, and nearly

white in color, and has a smooth base. It somewhat resembles a minute *Scalaria*. The six whorls are well-rounded, with deep sutures; the last whorl has four or five delicate revolving ridges, around the middle, but none on the base; the numerous and regular subsutural ribs cross two or more of the revolving ridges. The aperture is slightly angular and effuse in front, or sometimes even slightly notched. The inner lip is scarcely continuous posteriorly, or represented only by a very thin deposit on the body-whorl; no umbilicus. An examination of the soft parts and of the dentition shows that this is a genuine *Rissoa*, (as understood by Jeffreys and others, in the wider sense). But it seems to me better to adopt the name *Cingula*, as restricted by Gould, in 1841, for those species, mostly northern, which lack the opercular cirrus, and which, also, usually have thin shells, with no distinct rib on the outer lip. To this group belong nearly all our other New England species, viz: *C. aculeus* Gld., *C. multilineata* (St.), *C. castanea* (Möll.), *C. arenaria* M. (=*R. exarata* St.), *C. carinata* M., *C. latior* M., *C. globulus* (Möll.). No true *Rissoa* has yet been found on the Northeastern coast of America.

Cingula castanea nob., (=*Rissoa castanea* Möller).

This species I have dredged at Eastport, Me. (1864). Professor Cleveland took it at Mt. Desert, Me.; and Mr. Whiteaves in the Gulf of St. Lawrence. It is sometimes white.

Acirsa costulata nob., (=*Turritella costulata* Mighels, 1841).

The species, very well described and figured by Mighels, is undoubtedly identical with *A. borealis* Beck, MSS., and *A. Eschrichtii* (Möll. 1842) of authors. The name given by Mighels appears to have priority of publication. It is not uncommon off the coast of Maine, in 10 to 90 fathoms.

Leptochiton alveolus (Sars) Lovén.

Mr. W. H. Dall has detected this species among specimens dredged in the Gulf of Maine, in 150 fathoms, by Dr. A. S. Packard, for the U. S. Fish Commission, on the "Bache," in 1872. He also informs me that he has received it from the Gulf of St. Lawrence, 220 fath., (Coll. Whiteaves).

Leptochiton cancellatus (Sby.) H. & A. Adams.

Mr. Dall has identified, as probably of this species, an immature specimen dredged by me, in 1877, off Halifax, N. S., in 95 fath., while on the U. S. Fish Commission.

Doris repanda Alder and Hancock, (=*D. planulata* Stimpson).

A critical examination of the dentition of this species shows that the American specimens are perfectly identical with the European.

Acanthodoris ornata Verrill, sp. nov.

Length about 1 inch, or 25^{mm}; breadth 8^{mm}. Body elongated, high at the sides, somewhat oblong; but narrower and obtusely rounded behind, extending much beyond the mantle; mantle much smaller than foot, broadly rounded in front, and expanded into rounded antero-lateral angles, narrowed and often incurved in middle and again expanded opposite the gills, covered with small, conical papillæ, except on a smooth area on the middle of the back, extending from the gills to the tentacles. Frontal veil broad, angular, with four distinct, but small, papilliform processes, two directed forward and two at the prominent outer angles. Dorsal tentacles long, slender, tapered at the end, length, nearly equal to breadth of body (6^{mm}), the lower half smooth, the distal half with about sixteen strong lamellæ, and a terminal rounded papilla; sheaths rudimentary, with very small papillæ. Gills eight, large, broad, in expansion exceeding the breadth of the body, bipinnate, finely divided, the two posterior ones smaller, all united by a basal web; anal area smooth. Color, translucent yellowish flesh-color, specked with yellow and brown; bases of papillæ surrounded by brown; dorsal smooth area brownish (due to viscera); gills pale flesh-color, with flake-white at their bases; tentacles pale, their lamellæ brownish yellow. (Description from living specimen).

Eastport, Me., at low water, Aug. 19, 1872. Collected by the writer while with the U. S. Fish Commission. Drawings were made by Mr. Emerton, and the writer.

Allied to *Doris* (*Acanthodoris*) *subquadrata* Alder and Hancock.

Acanthodoris stellata nob., (=*Doris stellata* Gmelin.)

Doris (*Acanthodoris*) *pilosa* Alder and Hancock, Plate 15, figs. 1–10 (*non Doris pilosa* Müller).
Doris bifida Verrill, this Journal, vol. 1, p. 406. (Variety).

Typical specimens of this species have been repeatedly collected and carefully examined by me, from various parts of the New England coast (New Haven to Eastport, Me.), and agree perfectly with the figures and descriptions by Alder and Hancock, except that the white stellate markings on the gills are usually absent. My *Doris bifida* is only a color-variety.

Acanthodoris citrina sp. nov.

At Eastport, Me., I have observed a more distinct form, probably a new species. In this the body is more depressed and elongated, elliptical; the frontal veil is crescent-shaped, with the angles much produced, and with two, more prominent, tentacular papillæ in front. Mantle covered with small, soft, conical, acute, yellow papillæ, with yellow granules between them. Branchiæ nine, broad, bipinnate and tripinnate, in expansion nearly reaching the sides of body, the two posterior

small, all united beneath by a short web. Color, pale lemon-yellow, specked with bright yellow; gills yellow; tentacles and edge of mantle orange. Length 25^{mm}; breadth 8 to 10^{mm}.

Adalaria proxima Bergh, (=*Doris proxima* Alder and Han.)

Specimens of this species were collected at Eastport, Me., by the writer and Professor S. I. Smith, in 1864, and also in subsequent years. They agree perfectly, both in external characters and dentition, with the English specimens.

Onchidoris muricata (Müller). H. and A. Adams.

Specimens, apparently identical with this species, were obtained at Eastport, Me., with the preceding.

Onchidoris diaphana (Alder and Han.)

Not uncommon at Eastport, Me., where I obtained it in 1864, '68, '70, at low-water, under stones.

Coryphella rutila, sp. nov.

A large, brilliantly colored species, remarkable for the small size of the head. Foot broad, pointed, but not much elongated posteriorly; auricles very long, often equal to breadth of foot, slender, acute, with a fold or groove in front. Head small, rounded, often emarginate in front, with the mouth large and subterminal. Oral tentacles arising from sides of head, slender, elongated, tapering, slightly wrinkled; dorsal tentacles slightly stouter and longer, wrinkled, arising near together; eyes not observed. Branchiæ numerous, long, rather slender, slightly fusiform, arranged in eight to ten, usually well-separated, transverse clusters, mostly of two rows each, usually six to eight in each row; anteriorly the clusters become more crowded. Color, yellowish white, translucent; branchiæ with a bright vermilion nucleus, the tips, for some distance, flake-white; dorsal tentacles pale yellowish, usually tipped with white. Length, 48^{mm}; breadth, 7^{mm}; dorsal tentacles, 10^{mm}; oral, 9^{mm}; branchiæ, $9{\cdot}5^{mm}$.

Eastport, Me., 1864, 1868, 1872, found at low-water, sometimes under stones, but often entirely exposed, creeping over algæ. It is allied to *Æolis pellucida* Alder and Hancock.

Cuthona Stimpsoni, sp. nov.

A species of *Cuthona*, allied to *C. Peachii* Ald. and Han., is not uncommon at Eastport, Me., where I have observed it in 1865, '68, '70 and '72. The tentacles of both pairs appear to be longer than in the English species, and the head to be more produced laterally. The foot is broad, not very acute nor slender posteriorly; auricles small, short, triangular, often directed backward. The head is large, broad, rounded in front, with dis-

tinct rounded lateral lobes. Tentacles slender, slightly wrinkled; branchiæ numerous, crowded, fusiform. Color, yellowish white, with a flake-white line on the upper side of foot, posteriorly; tentacles tinged with salmon, with flake-white specks or a streak, distally; branchiæ with salmon, yellowish brown, reddish brown, or purplish nucleus, and specked at the end with flake-white, which sometimes forms a ring, near the tip. Length, 10 to 32^{mm}.

ART. XL.—*On the Presence of Chlorine in Scapolites;* by FRANK D. ADAMS. *Contributions from the Laboratory of the Sheffield Scientific School.* No. LIV.

IN the present paper I wish to call the attention of mineralogists to a fact which appears to have been hitherto almost entirely overlooked, namely, the presence of chlorine in minerals of the scapolite family. In a paper which appeared in the Annalen der Chemie und Pharmacie, xlvi, p. 340, 1843, Dr. Carl Schafhäutl details the results of his examination of "Porzellanspath." It was called passauite by Naumann, and classed in Dana's Mineralogy as an altered ekebergite. The mineral was first analyzed and made a distinct species by Fuchs, who, in his Mineralogy, published in 1842, assigns to it the formula

$$4\dddot{\bar{A}}l\,\dddot{\bar{S}}i + 4\dot{C}a\,\dddot{\bar{S}}i + \mathrm{Cl\,Na},$$

which requires 7·83 per cent of sodium chloride. He, however, supports the formula by no analyses. Dr. Schafhäutl employed several methods in determining the chlorine. In one, the powdered mineral was heated in a retort with concentrated sulphuric acid and the distillate caught in a tube containing silver nitrate. This method required care, but gave good results. He then tried fusion with barium carbonate, or sodium carbonate. Only a little chlorine was found when a red heat was employed, and none at all when a white heat was given. But a satisfactory result was obtained by fusing with barium carbonate in a very thin platinum crucible, some of the carbonate being placed on top of the mixture, and the heat supplied by a Fuchs spirit lamp. The quantity of chlorine in the mineral was found to be ·924 per cent, an amount just sufficient to saturate the potassium present. From his analysis he deduced the following formula:

$$4(Al_2O_3,\ SiO_3) + \left\{ \begin{matrix} 2(CaO,\ SiO_3) \\ NaO,\ SiO_3 \end{matrix} \right\} + \tfrac{1}{5}KCl_2$$

This analysis of Dr. Schafhäutl's is the only one in the lists of analyses of scapolites given in Dana's Mineralogy, in which chlorine is mentioned as one of the constituents.

This winter a duplicate analysis of a scapolite from lot 13 of the 8th concession of the township of Ripon, Quebec, was made by the writer, but it fell short of 100 by several per cent. Thinking that a loss must have been incurred at some step in the process, the analysis was repeated, but the results were much the same. The mineral was then tested for fluorine by the method described in Fresenius' Qual. Anal., p. 218, 7, but none was found. It was noticed, however, that by heating the powdered mineral alone in a platinum crucible, a heavy sublimate was obtained which collected in a drop on the cover of the crucible. This sublimate was soluble in water, the solution gave a precipitate with silver nitrate and also one with barium chloride, thus showing the presence of chlorine and sulphuric acid in the mineral. A complete analysis of the mineral was again made in duplicate; this time the chlorine and sulphuric acid were determined, and it was found to sum up satisfactorily. The scapolite occurs in veins varying in width from a few inches to a foot. It is associated with blackish mica, green hornblende, colorless quartz, reddish calcite, green apatite, black tourmaline, and frequently incloses small crystals of brownish sphene. The opening from which the specimens were taken was made in search of apatite, which occurs in the vicinity both in crystals associated with blackish mica and reddish calcite, and also in the finely granular form known to the miners as "sugar phosphate." A portion of one of the apatite crystals was examined and found to contain chlorine. The color of the mineral is white, sometimes greenish-white.

The scapolite occurs in rather large crystals, the exterior portions of which are evidently somewhat decomposed, while the interior is apparently unchanged. It fuses with intumescence at about 3. The lustre of the undecomposed mineral on the basal surface of fracture is sub-vitreous, but elsewhere there is little lustre. The only cleavage observed was paralled to the lateral faces, which are deeply striated. Specific gravity of three specimens was as follows:—2·605, 2·654, 2·626. A portion having the strongest vitreous lustre was selected for analysis. A section made from a fragment of this was submitted to a microscopic examination by Mr. Hawes, who judged that the impurities were not present in sufficient quantity to cause any error in conclusions drawn from the results of analysis.* The chlorine and sulphuric acid were determined by fusing with sodium carbonate, and after digesting the fused mass with water, acidifying with nitric acid and precipitating the chlorine by silver nitrate. The excess of silver in the filtrate was then separated by hydrochloric acid, filtered off,

* Minute quantities of orthoclase and calcite were observed. No disengagement of carbon dioxide could be perceived when the powdered mineral was treated with hydrochloric acid.

and the sulphuric acid precipitated in the filtrate by barium chloride. Since as before mentioned alkaline chlorides are lost by igniting the mineral strongly, the elongated slightly conical crucible designed by Dr. Smith for his alkali determinations, was made use of in estimating the water. The mineral was dried over sulphuric acid in a platinum boat, introduced into this crucible and kept at a bright red heat over a fish-tail Bunsen lamp until it ceased to lose weight. The flame of a Bunsen lamp was occasionally passed across the mouth of the crucible but no yellow coloration was imparted to it, and on rinsing out the crucible with distilled water only a trace of chloride was found in solution. The remaining constituents were determined in the usual way.

The results of the analyses are as follows:

	I.	II.	Mean.
SiO_2	54·859	54·858	54·859
Al_2O_3	22·128	22·769	22·448
Fe_2O_3	·486	·486	·486
CaO	9·164	9·020	9·092
MgO	trace.	trace.	trace.
K_2O	1·241	1·013	1·127
Na_2O	8·358	8·373	8·365
Cl	(2·473) 2·485	2·276	$\frac{1}{3}$ 2·411
SO_3	·823	·770	·796
H_2O (comb.)	·143	·139	·141
H_2O (hygr.)	·722	·723	·722
	100·409	100·427	100·447
Deduction for O replaced by Cl,	·59	·59	·59
	99·819	99·837	99·857

Assuming chlorine and sulphuric acid to be combined with sodium, the atomic and quantivalent ratios calculated from the mean of the above analyses, are:

	Atomic.	Quantivalent.		
Si	914 × 4	3656		3656
Al	438 × 3	1314	1332	
Fe	006 × 3	18		
Ca	162 × 2	324	324	1886
Na	206	206	230	
K	024	24		
NaCl	068			
Na_2SO_4	010			
H_2O	032			

Excluding NaCl and Na_2SO_4, the quantivalent ratio for basic elements and silicon is 1886 : 3656 = 1 : 1·94, approximately that required by a bisilicate (1 : 2). It is therefore more acidic than any of the members of the scapolite family with the exception of dipyre and marialite.

As many of the analyses given in Dana's Mineralogy foot up to less than 100, some of them being as low as 97 and 98, it

was thought that the deficiency might be due to chlorine, which had been overlooked in the analyses. Accordingly fourteen specimens of scapolite, from different localities, were selected and examined for this element. It was found in every case, though in some of them the amount present was small. They were tested by heating some of the finely pulverized mineral to whiteness in a platinum crucible, by means of a powerful blast lamp, the flame being slanted so as not to heat the upper portion of the crucible more than necessary. The sublimate obtained on the cover was dissolved in water and the usual tests applied. In the following table the percentage results of the examination of the scapolites are tabulated. A dash indicates that the constituent referred to has not been tested for.

	Chlorine.	Sulphuric Acid.	Loss on ignition at a red heat.	Carbonic Acid.
Gouverneur, N. Y.	Cl. pres.	——	——	None.
Lewis Co., N. Y.	" "	——	——	——
Edenville, Orange Co., N. Y.	" "	——	——	CO_2 pres.
Monroe, Conn.	" "	——	——	——
Bolton, Mass., (Pink scap.)	" "	——	——	CO_2 pres.
" " (Whitish ")	" "	——	——	" "
Pierrepoint, N. Y.	" "	H_2SO_4 pres.	——	——
Meionite, Mt. Somma, Italy.	" "	" "	——	——
Arendal, Norway.	" "	" "	——	CO_2 pres.
Malsjö, Wermland, Sweden.	" "	" "	——	" "
Templeton (21st lot of 12th range) Queb., massive and banded.	" "	" "	——	" "
Ripon (13th lot of 8th range) Quebec. High lustre.	2·411	·796 (SO_3)	·722	None.
Ripon (13th lot of 8th range) Quebec. Less lustre.	1·468	——	1·496	CO_2 pres.
Ripon (13th lot of 8th range) Quebec. Less lustre.	2·011	——	——	" "
Hull (8th lot of 14th range) Quebec.	·2026	H_2SO_4 pres.	——	" "
Trumbull, Conn.	(?) 1·783	——	·337	None.
Kokken, near Krageröe, Norway.	2·013	H_2SO_4 pres.	(?) 1·903	CO_2 pres.
Passauite, Passau (Schafhäutl.)	·924	——	1·2 (water)	——

Dr. B. J. Harrington informs me that he has found chlorine in other scapolites from the township of Templeton, Quebec, both in crystallized and massive specimens, though he has not determined the amount present. When the mineral contains only a small quantity of chlorine, as in the cases of the specimens from Arendal, Malsjö and Templeton, it cannot be detected with certainty by igniting the mineral, but it is easily found by Rose's method, which will be mentioned farther on. In order to ascertain what quantity of chlorine must be present in the mineral to be detected by the ignition test, the scapolite from

Hull, which gives off only a trace on ignition, was examined by Rose's method and found to contain ·202 per cent of chlorine. It is therefore probable that those specimens, whose sublimate gave a distinct precipitate with silver nitrate contained above that amount. In every case in which the sublimate was tested with barium chloride, a white precipitate was obtained. In the scapolite from Ripon this was due to sulphuric acid contained in the mineral, but in other cases it may possibly have been due to fluorine. The blue sodalite occurring at Litchfield, Me., loses alkaline chlorides when ignited, in the same manner as the scapolites. The sublimate contains a trace of sulphuric acid in addition to the chlorine. A specimen of wilsonite, from Bathurst, Ont., when subjected to the same test, gave no sublimate, but another specimen of the same mineral from the fifth lot of the tenth range of Hull, Quebec, gave a slight sublimate which contained a trace of sulphuric acid, but no chlorine. The meionite mentioned in the table gave a comparatively heavy sublimate.

Dr. Schafhäutl, in his paper referred to above, states that his "Porzellanspath" lost all its chlorine when fused with sodium carbonate at a white heat, and that only a trace remained if a red heat was employed. In order to ascertain whether my analysis was deficient on this account, I determined the chlorine in a white scapolite from Trumbull, Conn., both by fusing it with sodium carbonate, over a powerful circular Bunsen lamp, and also by Rose's method. This method consists in decomposing the mineral in the cold by hydrofluoric acid in the presence of weak nitric acid. The calcium fluoride is filtered off, and the chlorine determined in the filtrate by precipitating with silver nitrate. The results were as follows :—

By decomposition with hydrofluoric acid.........	1·824	per cent.
By fusion with sodium carbonate...........	1·756	"
Difference........................	·068	

The loss is therefore very small. The scapolite from Ripon is not easily decomposed by sulphuric acid. In an experiment conducted by Mr. Comstock in this laboratory, two grams of the finely pulverized mineral were treated with concentrated sulphuric acid for three hours and a half at a temperature between 160° and 200° C., but only a trace of chlorine was given off. Dr. Schafhäutl also states that at a red heat every trace of chlorine was expelled from his mineral, and that some of the chlorides were dissolved out by water. That such is not the case with all scapolites is seen from the following experiments conducted on the same material from Ripon: ·87 of a gram was heated to intense whiteness in a platinum crucible and fused down to a transparent, colorless, vesicular mass. It lost 5·178

per cent, but the residue gave a heavy precipitate with silver nitrate when examined by Rose's method. It was found that only a very small quantity of the chlorides escaped at a high red heat, a white heat being required to expel them in large quantity, although even at that temperature some remain as proved by the last experiment. About half a gram of the finely powdered mineral was treated with cold distilled water for about forty-five hours, but not a trace of the chlorides went into solution. The scapolites mentioned in the table, which contain the highest percentage of chlorine, are generally sound and undecomposed. Two specimens of the Ripon mineral, with little or no luster, were found to contain less chlorine than an undecomposed specimen with a high lustre. Fuchs states that the "Porzellanspath," examined by him, lost a portion of its chlorides on decomposition. The specimen from Hull, which contained only ·202 per cent, was almost entirely devoid of lustre and contained carbon dioxide. It is therefore highly probable that chlorine is lost, and not gained by the decomposition of the scapolite minerals.

It is possible that in some cases at least the failure of scapolites to give a good formula, may be due to the fact that sufficient alkali to combine with the undetermined chlorine present has not been deducted before attempting to deduce the formula.

My best thanks are due to Professor Allen, who has kindly directed this investigation.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *On the Formation of Mountains and the Secular Cooling of the Earth;* by G. H. Darwin.—The letters of Mr. Wallace and Mr. Fisher in Nature, vol. xix, pp. 121, 172, 244, 267, raise the question as to whether or not it is possible that the interior of the earth can be cooling more rapidly than the exterior. The following is an attempt to answer the query as to where the loss of temperature per unit of time is greatest.

Sir W. Thomson (see Thomson and Tait, "Nat. Phil.," App. D) considers the cooling of "a solid extending to infinity in all directions, on the supposition that at an initial epoch the temperature has had two different constant values on the two sides of a certain infinite plane." The solution given is—

$$v = v_0 + \frac{2V}{\sqrt{\pi}} \int_0^{\frac{x}{2\sqrt{(kt)}}} e^{-z^2} dz$$

where k denotes the conductivity of the solid, measured in terms of the thermal capacity of the unit of bulk; V, half the difference

of the two initial temperatures: v_0, their arithmetical mean: t, the time; x, the distance of any point from the middle plane; v, the temperature of the point x at time t.

The above solution shows that for all values of the time when $x=0$, $v=v_0$, so that the temperature at the medial plane is constant.

Then differentiating v with regard to the time we have—

$$-\frac{dv}{dt}=\frac{V}{2\sqrt{(\pi k)}}\ \frac{x}{t^{\frac{3}{2}}}\ e^{\frac{-x^2}{kt}}.$$

This expression is that required for the rate of cooling. We now wish to find where it is a maximum. Consider the function $z\,e^{-z^2}$; this is clearly a maximum when $\log z - z^2$ is a maximum, and by the ordinary rules this is a maximum when $\frac{1}{z}=2z$, or when $z^2=\frac{1}{2}$. Hence it follows that $-\frac{dv}{dt}$ has its maximum value where $x^2=2kt$. Now when the unit of length is a foot and of time a year, $k=400$; hence $x=\sqrt{800t}$.

This formula shows that the seat of the maximum rate of cooling moves inward as the time increases. If the time which has elapsed from the initial state be two hundred million years, or $t=2\times10^8$, we have $x=400{,}000$ feet, or a little less than eighty miles.

Sir W. Thomson shows, in his paper on the Secular Cooling of the Earth, that the solution of his ideal problem will be very nearly correct for the case of the earth, which is supposed to be a hot sphere cooling by radiation. It follows, therefore, from the numerical result which is given above that the seat of the maximum ratio of cooling must probably be something like 100 miles below the earth's surface. It does not, of course, necessarily follow that the seat of the maximum rate of contraction of volume should be identical with that of the maximum rate of cooling; yet it seems probable that it would not be very far removed from it.

The Rev. O. Fisher very justly remarks that the more rapid contraction of the internal than the external strata would cause a wrinkling of the surface, although he does not admit that this can be the sole cause of geological distortion. The fact that the region of maximum rate of cooling is so near to the surface recalls the interesting series of experiments recently made by M. Favre (of which an account appeared in Nature, vol. xix, p. 103), where all the phenomena of geological contortion were reproduced in a layer of clay placed on a stretched india-rubber membrane, which was afterwards allowed to contract. Does it not seem possible that Mr. Fisher may have under-estimated the contractibility of rock in cooling, and that this is the sole cause of geological contortion?—*Nature*, Feb. 6.

2. *On Binaural Audition.**—In a recent number of the Philosophical Magazine (March, 1879), STEINHAUSER discusses the theory of direct Binaural Audition. Some of his conclusions are stated as follows:

(1.) The direction in which a source of sound is situated, may be estimated by the different intensities with which a sound is perceived in the two ears. (2.) The standard of each individual for the perception of the direction of sounds is dependent upon the angle β, that is, the angle included between the effective surfaces of the pinnæ of the ears and the line of sight. (3). The smaller the angle included between the line of sight and the surfaces of the pinnæ, the more certain will be the perception of the direction of sound. (4.) We hear best with the two ears when the sound reaches us from the front in the line of sight. (5.) Persons equally hard of hearing in one ear must, in order to hear as well as possible, turn the better-hearing ear the more towards the speaker in proportion as the angle which the surfaces of their pinnæ make with the line of sight is less. (6.) The power of perception of the direction of a sound is not vitiated by an equal hardness of hearing in both ears. (7.) For most persons the angle β (above defined) is less than 30°, which explains the well-known position assumed by the listener who turns one ear towards the source of sound. (8.) We hear binaurally the best, relatively, when the source of sound is situated in that plane in which are situated the line of sight and the line joining the middle points of the pinnæ ("plane of best hearing") and the best, absolutely, when it is situated in the line of sight. (9.) In the case of hearing a sound coming from above or below, we are able to estimate, from the relative intensities with which the sound is perceived in the two ears, the azimuth of the rays of sound as projected upon the plane of best hearing.

The last principle explains the method which we pursue to discover the position of a source of sound whose situation is unknown, and which consists in a motion of the head.

For example, to find a source of sound situated anywhere *above*, we have only to turn the head about a vertical axis until we hear equally with both ears and with the greatest total intensity. Then the line of sight coincides with the horizontal projection of the direction of the sound. The head must then be turned upwards about a horizontal axis at right angles to the line of sight, as long as the intensity of the sensation increases. When this reaches its maximum, and is equally great for both ears, then the source of sound must be situated in the line of sight. And here we must remark on the essential importance of the actual conditions—that the ears and eyes, being alike attached to the head, share its movements, and that they are situated at almost the same height above the ground.

Should we perceive a falling-off in the intensity of the sound on raising the head, this would be an indication that the source of

* See this Journal, January, 18.9, p. 64.

sound is situated *below* the plane of best hearing, and that we should be able by sinking the head to bring the source of sound into the line of sight in the manner just described for a sound above the head.

It is intelligible and natural that, where (as in an instrument for measuring altitude and azimuth) we have two separate motions of rotation at right angles to one another, it is immaterial whether the movements in the two directions be executed separately or by a simultaneous motion of the head. This occurs, for example, when we try to find a lark which we may hear singing above a field. We raise the head, making an arbitrary guess at the position of the lark in the sky. Then we turn the head about, led meanwhile *by ear* until we hear equally well with the two ears and with the greatest possible intensity; and simultaneously we perceive the lark in the line of sight. We do not, therefore, as it might be conjectured in this case, seek for the source of sound by means of the eyes, but *by means of the ears.*

3. *The Faraday Lecture before the Fellows of the London Chemical Society*, November 12, 1878, by Professor AD. WURTZ of Paris, is published at length in the January number of the Journal of this society. The subject chosen was "Constitution of Matter in the Gaseous State," and is significant after the discussions of the fundamental principles of modern chemistry which have taken place in the French Academy, and to which we have before referred in these pages. The lecture was an elementary exposition of the dynamical theory of the constitution of matter, and of the conception of molecules and atoms which this theory involves, and which Professor Wurtz fully accepts as the theoretical basis of the philosophy of chemistry. The lecture was illustrated, and its chief interest centers in one of the experiments, which, as it would seem, gave a very different result from that obtained by M. Troost from a series of similar experiments, noticed on page 321 of vol. xvi, III, of this Journal. Into the space above the mercury of one barometer-tube chloral-hydrate was evaporated, while the similar space of a second tube was filled with the vapor of chloroform. Into both of these atmospheres crystallized potassic oxalate was then introduced. Very soon a depression of the mercury column indicated that the water of crystallization of the salt had evaporated into the dry vapor of chloroform, while the constancy of level in the first tube showed that into the vapor of chloral-hydrate no such evaporation had taken place. Hence the conclusion that the space above the mercury in the first tube was already saturated with free aqueous vapor, and therefore that chloral-hydrate must become disassociated when it evaporates. By a reference to loc. cit. the bearing of this experiment will be more plainly seen, and the contradiction presented will serve to enforce the lesson, there suggested, that exceptions to a law so well established as that of the equality of molecular volumes in the aëriform state ought always to be very closely scrutinized.

At the same time with the address of Professor Wurtz we have before us a similar address by Professor Bayer, the successor of Liebig at Munich, and one of the most distinguished representatives of the German School of Organic Chemistry. It was delivered before the Königl. Akademie der Wissenschaften on the occasion of the birthday of King Ludwig of Bavaria, and is reprinted, with no flattering comments, by Professor Kolbe in the December number of the Journal für prakt. Chemie. The nominal subject of the address was "Chemical Synthesis," and we should have expected that, before such an audience, the eminent chemist, who had so recently made the synthesis of indigo blue, would have dwelt on the philosophy of the method by which this great result had been obtained; and, certainly, the circumstances connected with the synthesis both of indigotine and of alizarine illustrate most strikingly the great value of even the conventional forms of a well grounded "working hypothesis" in guiding scientific investigation. But, so far from this, the address was, for the most part, another popular exposition of the same subject treated by Professor Wurtz, and it contains such grotesque fancies that we can scarcely credit that the words we read were actually addressed to a learned society, even if in open session. We read of systems of atoms branching like trees—as if they were objects of natural history; of the possibility that the molecules of the diamond are large enough to be seen with a microscope, and to be isolated by mechanical pulverizing; of the molecules of marsh-gas as attaining sufficient velocity to carry them beyond the sphere of the earth's attraction, and that the exhalations of our marshes may thus contribute to form those cometary masses in which the spectroscope has discovered the presence of carbon. It would seem as if the purpose of the address were to bring the molecular theory into disrepute by a "reductio ad absurdum;" and while we cannot but regret the rude manner in which Professor Bayer has been ridiculed in the reprint to which we have referred, the address certainly invites criticism, and shows how absurd a good "working hypothesis" may be made to appear if we insist on realizing its conventional and temporary forms. No partial truths will bear such treatment, and these two addresses seem to us worthy of notice in this place as pointing out very clearly the only legitimate use of theory which forms the basis of our modern chemical philosophy. J. P. C.

4. *Experimental determination of the velocity of Light;* by A. A. MICHELSON, U. S. N., Instructor in Physics and Chemistry in the United States Naval Academy.—In a former number of this Journal (May, 1878, p. 394) a brief description is given by Mr. Michelson of a new method for the experimental determination of the velocity of light. It is based upon the method of Foucault so modified, as there described, as to admit of the use of any distance between the mirrors, and a correspondingly increased displacement of the reflected image. This method has since been put to use by the describer. In his experiments the speed of the mirror was 130

turns per second, the radius of measurement from fifteen to thirty feet, and the distance between the mirrors 500 feet. The displacement varied from 0·3 inch to 0·63, or about twenty times that of Foucault. The mean of ten determinations for the velocity of light in air was 186,508 feet, the extremes being 184,500 and 188,820. The author expresses the hope of being able, under more favorable conditions, to obtain the true result within a few miles.—(*Amer. Assoc. Adv. Science, St. Louis meeting*, 1878.)

II. Geology and Mineralogy.

1. *Note on Mountain-making by the Contraction of the Earth's crust;* by J. D. Dana.—A method of reproducing on a small scale the folding and fracturing of strata has been contrived by Professor A. Favre, of Geneva (Nature, of Dec. 5, from La Nature). He employs a stretched sheet of caoutchouc, to which clay in thin layers has been made to adhere, and allows it gradually to contract to its natural condition. The figures of the results, which he has published, represent foldings, faultings and crushings that look much like some of the effects in the world of rocks.

Mr. H. F. Walling, of Cambridge, in a paper on the relation of adhesion to horizontal pressure in mountain dynamics, read before the American Association at St. Louis in August, 1878, and published recently, suggested, still earlier, essentially the same mode of experimenting.

There are two general facts with regard to *actual* mountain-making that are not in accordance with the results which the caoutchouc affords.

(1.) Contraction in the earth's crust from cooling must have gone on continuously through time, with local differences, especially between the continental and oceanic areas, but still continuously; and therefore the effects, if like those on the caoutchouc, should have occurred all along the ages over the globe. But the fact is, that mountain-making has occurred over the continents only after a very long, quiet interval in which there were no disturbances beyond those from gentle oscillations. Geology has found that, for North America, from the Atlantic south of New York to the Rocky Mountains, and as the facts now stand, to the Pacific, there was but one mountain-making epoch between the close of Archæan time and the beginning of the Triassic era; and that this occurred at or near the termination of Paleozoic time. Thus, for the larger part of the broad continent, at least *three-fourths* of all geological time after the Archæan—amounting to seventy-five millions of years, if the whole covered one hundred millions—passed without any mountain-making disturbance, the greatest of which there is evidence, being that which raised the Lower Silurian about Cincinnati and to the northeast and southwest. During all that long time the sedimentary deposits were slowly thickening over the underlying crust, and lay like the clay over

the caoutchouc, but this supercrust was nowhere bent up into steep folds or bold wrinkles through the contraction in progress.

There was probably disturbance and mountain-making in the Green Mountain region after the close of the Lower Silurian; and it is possible that effects of the same disturbance will be found along the eastern part of the Appalachian region farther south. But, if so, the general truth remains the same; for the close of the Lower Silurian occurred about half way between the Archæan and the close of the Carboniferous, making the antecedent period of quiet, on the above estimate of time, nearly forty millions of years. Over the Rocky Mountain region it is not yet proved that any great disturbances occurred at either of these eras, the first in the Wahsatch and Uintah region taking place not before the close of the Cretaceous.

(2.) The folds often have all the steeper inclinations facing in one direction and the less steep in the opposite, showing that the results of the pressure were unlike in the two opposite directions. The well known facts in the Appalachians, as first announced by Professor Rogers, abundantly illustrate this, and, also, those in the Jura Mountains.

The results obtained with the contracting caoutchouc correspond in one respect with rock-flexures, and it is a point not always considered by those who speculate on mountain-making. In mountain regions the flexures in the earth's strata are not, with very rare exceptions, represented by like flexures in the contracting crust. The former are generally between one and twenty miles in span; and the earth's crust could not have been thin enough at the close of the Paleozoic, when the Appalachians were formed, to have made such narrow bendings.

2. *Notes on the Coral Reefs of the Island of Itaparica, Bahia, and of Parahyba do Norte;* by RICHARD RATHBUN.—In the American Naturalist for July, 1876, I gave a short description of the coral reef skirting the outer shore of the island of Itaparica, in the bay of Bahia, Brazil. From a further examination of the reef and a study of the specimens procured from it, I am able to add a few items of interest to those previously given. I also wish to call attention to the existence of another reef, similar to that of Itaparica, to the south of the entrance to the Rio Parahyba do Norte. It was explored by Mr. John Branner of the Geological Commission. In shape and structure, as well as in the paucity of coral life upon it, this last agrees very closely with the Itaparica reef. It follows the trend of the shore, at a short distance from it, and between the reef and the shore there is an average depth of water of about six or seven feet only. The upper and outer portions of the reef are very irregular, but the inner part is comparatively smooth. No large corals are living upon it; at the northern end were collected a few small specimens of Porites, and toward the south a few Millepores, Symphyllia (?), and Porites. Much of the bottom surrounding the reef is very rich in coral growth. No sections were obtained giving us a clue to its

structure, which is, however, probably the same as that of the Itaparica reef.

In my former description of the Itaparica reef I stated that, while the lower portion was plainly made up in large part of true corals, the upper part appeared to contain only nullipores. I have since found that the worm tubes covering the surface of the reef enter very largely into its structure, probably to as great an extent as the nullipores, and give rise to an exceedingly hard, calcareous rock from which, ultimately, all traces of the worm-tube structure disappear. The worm-tubes and nullipores evidently compose the entire upper half of the reef. The nullipores, in the upper portions, so far as my observations went, were all of the encrusting lichen kind, and resulted in a compact structure, showing a sort of wavy lamination which is due to the successive growths of nullipores. The large digitate nullipores, so common at Pernambuco and at many places in the Bay of Bahia, are limited to the lower part of the reef, where they are associated with the true corals. At present nullipores are living in abundance only on the outer side of the reef, to a height of about one foot above medium low tide. Above the line of nullipores we find the entire upper surface of the reef coated with a layer of living worm tubes and large barnacles. The latter are generally broken off by the waves when dead, but the former remain, producing a loose structure near the surface, which becomes more compact below. The existence of nullipores in this upper portion indicates, however, that they lived on top of the reef at no distant time, and probably also that the reef has been elevated to a slight extent since then.

Within the reef the water is very shallow, being deepest near the reef and especially at and around the openings through it; it gradually shallows inward toward the beach. The bottom of this shallow inner channel is covered with sand and fragments of all sizes of corals and shells. Corals were not found in an upright position in this channel, nor do living corals exist there at all. The coral fragments are all old, frequently much worn, and almost invariably covered with nullipore and bryozoan growths, also dead. They form beds of considerable thickness in places, often more or less consolidated, and are dug up to burn for lime. The species discovered among the fragments are all found living in various parts of the bay, excepting *Mussa Harttii*, which does not apparently live at present anywhere in the Bay of Bahia. This extensive accumulation of broken corals, which must have been formed by the breaking off and heaping up of living corals from the surface of the reef by the breakers, when the reef was at a lower level, testifies to the exceeding richness of the coral life at that time. Corals have apparently ceased to be reef-builders in the Bay of Bahia.

3. *Semi-metamorphic fossiliferous rocks containing Serpentine.*—Dr. J. W. Dawson mentions facts on this subject from which the following are cited.

On the Saguenay River, at Lake Chebogamong, there is a band of serpentine associated with limestone; and Mr. Richardson obtained there a fossil tabulate coral which has part of its cells filled with serpentine, and also veins of serpentine intersecting it. The species is *Astrocerium pyriforme*, a species very common in the Upper Silurian limestones of the region in which it occurs, and characteristic especially of the Niagara formation. The formation containing the serpentine and limestone "is described as consisting of chloritic slates, in some places with hornblende crystals, dolomites, and hard jaspery argillaceous rocks."

At Melbourne, in the province of Quebec, rocks, referred by Logan to the Quebec group, pass upward into a thick series of hydromica schists, associated with quartzose bands and lenticular layers of crinoidal limestone. Over these, according to Logan, lies serpentine in thick beds (undoubtedly bedded rocks and not "eruptive") with other hydromica schists, limestone breccia, arenaceous beds, beds of anorthite, steatite, dolomite and red slates. The serpentine in the line of strike passes into dolomite and red slate. Fossils occur in the limestone interstratified with the serpentine, and also disseminated serpentine. The fossils are "*crinoidal* joints, fragments apparently of *Stenopora*," and tubular bodies which may be portions of *Hyolithes* or *Theca*, having an interior of calcite and a coating of serpentine. The cells of the fossils are sometimes filled with the serpentine; and the crinoidal joints are surrounded by it, with dolomite within.

Slices of these specimens, and those of other localities, were made by Mr. Weston when under the direction of the late Sir W. E. Logan. The other localities include Stamford, Farnham, Cleveland, Bedford, Oxford, Athabaska, Point Levi, Rivière du Loup, in most of which Lower Silurian fossils occur associated with hydrous silicates.

A locality at Pole Hill, in New Brunswick, discovered by Mr. C. Robb, has afforded specimens consisting of "fragments of crinoids and shells finely injected with an olive-green hydrous silicate of alumina, iron and magnesia. In one shell, apparently an *Orthoceras* or *Theca*, the dark green filling has cracked in the manner of Septaria [as often true of crinoidal stems in the Subcarboniferous of the Mississippi valley] and the fissures have been filled with carbonate of lime.

4. *The Physical History of the Triassic Formation of New Jersey and the Connecticut Valley*; by I. C. Russell (Ann. N. Y. Acad. Sci., i, 220–254).—The author, after giving some account of the Triassic formation of New Jersey and the Connecticut Valley, discusses the origin of the westward dip of the former and eastward of the latter. He adopts the hypothesis, suggested by Professor Kerr for the Trias of North Carolina, and by Professor F. H. Bradley for the regions of which Mr. Russell treats, that the New Jersey and Connecticut beds are opposite parts of an anticlinal. He holds also that the sandstone was once continuous over the whole intermediate region. The view is sustained on the ground

that the dip of the sandstone is in opposite directions in the two areas—10° to 15° northwestward in New Jersey, 5° to 50° [averaging 15°] to the eastward and southeastward in the Connecticut Valley; and on the view of a conglomerate on the western border of the former and eastern of the latter, whence it is inferred that here were the coast lines of the great estuary. Calculations from the dip give him for the thickness of the sandstone 25,000 feet, the consideration of faults in the beds being rejected by the author as without "plausible" support.

The hypothesis has objections, some of which, as they appear to the writer, are here stated.

(1) A thickness of 25,000 feet of water-made sandstone over an area of metamorphic rocks more than 100 miles in width, large portions of which are now several hundred feet above the sea-level, implies a subsidence of this region of over 25,000 feet, during the formation of the sandstone, or else, this depth of water.

(2) It implies also an elevation of the whole region—100 miles wide between the eastern and western limits—not only to this amount, 25,000 feet, but enough higher to give the average pitch of 15° eastward in the eastern sandstone and 10° to 15° in the western. For a width in the Connecticut Valley of fifteen miles (the area averages twenty), the dip produced by the alleged uplifting if only 14°—supposing no faults—would put the *western side of the Connecticut Valley* 20,000 *feet above its eastern;* and the site of New York City, on the eastern 15,000 or 20,000 feet above its present level, with 25,000 feet of sandstone over it. How much higher such an elevation would place the central portion of the region between the Connecticut Valley and New Jersey, the reader can calculate. Mountains on the globe at the present day are small in comparison.

(3) The hypothesis asks for an incredible amount of denudation; crystalline rocks of great depth as well as sandstone, over an area more than fifty miles wide having to be removed, and the surface brought down to its present level.

(4) The southern limit of the Connecticut Valley sandstone area is *north of the northern* limit of the New Jersey. The New Jersey area cannot, therefore, be on the opposite margin of the sandstone region to that of the Connecticut Valley. That there should have been an opposite side to the Connecticut Valley anticlinal, the New Jersey Trias should have extended up the Hudson River to Albany, N. Y., 120 miles north of its most northern point, Albany being in the same latitude with its northern limit in the Connecticut Valley; and hence the whole of western Massachusetts as well as of Connecticut, and all of Eastern New York, south of Albany, including the Green Mountain region, must have been raised to the enormous altitude referred to; and, besides, the sandstone must have since been removed from the whole so that no trace was left, with the exception of the Southbury basin. Further, the opposite side of the New Jersey part of the arch must have been somewhere out in the Atlantic south of

Long Island; and this island must have participated in the upward bend.

It is however to be admitted that, with the suggested method of accounting for the dip in the Connecticut Valley sandstone, there was no need of any sandstone in the Hudson River Valley; and, no need, in fact, of any sandstone over the intermediate region of crystalline rocks between that valley and the New Jersey area.

(5) No evidence of such an anticlinal, or of the supposed amount of erosion, exists excepting this—that the sandstone of the Connecticut Valley dips eastward, and that of New Jersey, situated wholly to the south of the southern limit of the Connecticut Valley area, dips northwestward, at the angles stated.

The existence of a conglomerate along the eastern border of the Connecticut area can be accounted for on the usual view—that this area in Triassico-Jurassic times was a Connecticut Valley estuary, at the termination of the Connecticut River, and had its violent floods, which may have been for part of the time enlarged by the waters and ice of a semi-glacial era—quite as well as by that of its being the eastern part of a much larger estuary; and even better.

The features of the Connecticut Valley beds afford other arguments; but it is not necessary to bring them up at this time.

J. D. D.

5. *Geological Survey of Pennsylvania.*—The following volumes containing Reports of Progress of this survey, have been recently issued, in addition to that by Mr. C. A. Ashburner mentioned on a former page of this volume. They show great activity in the Survey.

I. *Report of Progress of Bradford and Tioga Counties* (G), 272 pp. 8vo, with maps and sections; including: 1. on the Limits of the Catskill and Chemung formations, by A. Sherwood; 2. Descriptions of Coal fields, by F. Platt; and 3, on the Coking of Bituminous Coal, by J. Fulton.

II. *Report of Progress in Indiana County* (HHH), by W. G. Platt, 316 pp. 8vo, with a colored map of the County. 1878.

III. *Catalogue of the Geological Museum*, Part I, Rock specimens. 218 pp. 8vo. 1878.

IV. *The Brown Hematite Deposits of the Siluro-Cambrian limestones of Lehigh County, lying between Shimersville, Millerstown, Schnecksville, Ballietsville, and the Lehigh River* (DD), by Frederick Prime, Jr.; 100 pp. 8vo, with 5 map-sheets and 5 plates. 1878.—Professor Prime, shows that the rocks of the region, above the Laurentian, are, in succession, (1) the Potsdam sandstone; (2) a Siluro-Cambrian magnesian limestone, which has afforded Chazy fossils, besides an Orthoceras and Lingulæ too imperfect for determination; (3) Damourite (Hydromica) slates, all in general conformable; also (4) the Trenton limestone, as a direct continuation of the magnesian limestone, the beds affording encrinital stems identical with those found in Northampton

County overlying characteristic Trenton fossils; and (5) Hudson River slates, also conformably continuous with the preceding. Professor Prime treats also of the origin of limonite beds associated with the damourite slates, and of other points in the geology of the region. His method of determining the age of the crystalline schists by means of the fossils in the conformably associated strata gives positive results.

V. *Special Report on the Trap-Dykes and Azoic Rocks of Southeastern Pennsylvania* (E), by T. STERRY HUNT. Part I. Historical Introduction. 254 pp. 8vo. 1878.—This Historical Introduction is a general exposition and re-statement of the author's views on the "Azoic," Cambrian and Silurian rocks, of this and other countries, and the application of lithology to classifying and fixing the age of the various crystalline rocks, besides notes on eruptive rocks, along with a historical account of former views on these and other subjects, and a statement of the observations from various sources that appear to favor the views set forth. It is valuable as a definite exhibition of the present state of such views in the science, and of the arguments—not always just to the observations of others—by which they are sustained. The progress of the science will show how much of truth there is in them.

J. D. D.

6. *Report of the Geological Survey of Ohio.* Vol. III, *Geology and Palæontology.* Part I, *Geology.* 954 pp. 8vo.—This large volume consists, after its Preface by Professor J. S. NEWBERRY, the head of the Survey, of a Review of the Geological Structure of Ohio by Professor Newberry, and chapters on the Geology of different counties by the same, and the Assistant Geologists, Messrs. J. J. STEVENSON, M. C. READ, A. W. WHEAT, EDWARD ORTON, JOHN HUSSEY, F. C. HILL, A. C. LINDEMUTH, J. T. HODGE and H. HERZER, with supplemental Reports by E. B. ANDREWS and E. ORTON.

From Professor Newberry's Review we take the following conclusions.

The Cincinnati group does *not* represent the Hudson River group of New York, but the whole Trenton series, including the Trenton limestone and Hudson River group.

Many fossils of the Oriskany sandstone in Canada West, as *Spirifera arenosa*, *S. arrecta*, *Rensellaeria ovoides*, and *Avicula arenosa* are found mingled with *Favosites Gothlandica*, *Zaphrentis prolifica*, *Conocardium trigonale*, *Platyceras nodosum*, and many other well known fossils of the Corniferous limestone, which facts, in addition to the entire absence of Upper Silurian species, prove the Oriskany to be much more closely allied to the Devonian than to the Silurian.

The "Black shale" or "Huron shale" of the Devonian is made up of the black shales of the Lower Portage and the Genesee. In the shale, besides the gigantic *Dinichthys*, the jaw of a large Placoderm has been obtained which has been referred to a new genus, *Diplognathus*, also a new species of *Dinichthys*, a new *Ctenacanthus*, and several of *Cladodus*.

The volume contains much of great value to the science that would be here cited but for the limited space.

7. *Journal of a Tour in Marocco and the Great Atlas;* by Sir JOSEPH DALTON HOOKER, President R.S., etc., and JOHN BALL, F.R.S.;—*with an Appendix including a sketch of the Geology of Marocco;* by GEORGE MAW, F.G.S., etc. 499 pp. 8vo. London: 1878. (Macmillan & Co.).—This volume contains an account of a journey made by Sir Joseph Hooker, Mr. Ball and Mr. Maw in 1871 to a region which, as the preface remarks, was then little better known to geographers than it was in the time of Strabo and Pliny. The general account of the journey, occupying the first 348 pages, contains, besides incidents by the way, much information on the features, vegetation, and people of the country. It is followed by Appendixes on the Geography of the region, by John Ball; on its economic plants, a comparison between the Flora of the Canary Islands and of Marocco, and between that of Tropical Africa and of Marocco, by J. D. Hooker; on the Mountain Flora of two valleys of the Great Atlas, by J. Ball; on the Geology of the plain of Marocco and the Great Atlas, by George Maw.

The geological chapter contains much on the glacier phenomena of the Atlas region. "Unquestionable moraines" were observed in the province of Reraya, at a height of 6,000 feet, where was a "gigantic ridge of porphyry blocks," "with no admixture of small fragments," 800 to 900 feet in vertical height, damming up the deep ravine. The beds of bowlders flanking the northern escarpment of the Atlas plateau spread downward in great mounds and undulating ridges from a height of 3,900 feet to the borders of the plain 1,900 feet above the sea; and the moraines, commencing at a height of 5,800 feet, stretch up the Atlas ridge to a height of between 7,000 and 8,000 feet. Behind the moraines, at 6,200 feet, there was observed a plain of shingle, which seemed to be the bed of a small lake. At present there is not even perpetual snow on any part of the Atlas range. Since the era of the glaciers, the coast line has been raised at least seventy feet, as indicated by raised beaches at Mogador "which may possibly be cotemporaneous with raised beaches on the coasts of Spain and Portugal." A slight subsidence of the coast-line is stated to be now going on.

8. *Annual Report of the State Geologist of New Jersey, for* 1878. 132 pp. 8vo.—The prominent feature of this Report is a chapter on the "Glacial and Modified Drift" of the State, which is illustrated by a large map, showing the surface covered by the drift, the course of the "terminal moraine," and the "Oak Lands" and "Pine Lands." It treats also of the soils of the State, clays and their compositions, clay deposits, glass sand, progress of the topographical survey of the State, and gives analyses of some iron ores and limestones.

9. *Geological Record for* 1876; *an account of works on Geology, Mineralogy, and Palæontology, published during the year; with supplements for* 1874 *and* 1875. Edited by WM. WHITAKER, B.A., F.G.S., of the Geological Survey of England.

415 pp. 8vo. London, 1878. (Taylor & Francis.)—The third volume of the Geological Record is fully up to its predecessors in scope and thoroughness. The value of the work, to all engaged in the sciences included, would seem to be so obvious that it is a matter of surprise and regret that the editor should be compelled to call for more subscribers to insure its continued success.

10. *The Study of Rocks; An Elementary text-book of Petrology;* by FRANK RUTLEY, F.G.S., of the Geological Survey. 319 pp. 12mo. London: 1879. (Longmans, Green & Co.).—The study of rocks by the microscope is now recognized as so important a part of lithology and so universally employed, that an English text-book giving the methods employed cannot fail to be appreciated. The work is about equally divided between the description of methods of making thin sections and of examining them in the microscope, the description of the rock-making minerals, and of the rocks themselves. Mr. Rutley's work is a convenient one for the student. It is not, however, free from errors; the description and figure on page 94 show that the mineral referred to must be *microcline* and not orthoclase.

11. *Ueber die Zusammensetzung der Lithionglimmer*, von C. F. RAMMELSBERG.—Professor Rammelsberg has made a new examination of the lithia mica, lepidolite, with special reference to the amount of alkalies present. He finds that many of the previous analyses are incorrect in the determination of the lithia, and in this respect he rejects the analyses of Berwerth upon which Tschermak based his recent conclusions as to the chemical formula (this Journal, III, xvii, 176). For the lepidolite of Paris, Me., and Rozena, Rammelsberg writes the formula $\overset{\mathrm{I}}{R}_2AlSi_3O_{10}$.—(*Ber. Ak. Berlin*, Oct. 28, 1878.) E. S. D.

12. *On the composition of Spodumene and Petalite;* by C. DOELTER.—Dr. Doelter has recently analyzed spodumene from Norwich, Mass., (1) and from Brazil (2) with the following results:—

	SiO_2	AlO_3	FeO	CaO	MgO	Li_2O	Na_2O	K_2O
(1)	63·79	27·03	0·39	0·73	0·21	7·04	1·10	0·12=100·41
(2)	63.34	27·66	1·15	0·69	...	7·09	0·98	..=100·91

After making allowance for impurities, he obtains for the quantivalent ratio of $\overset{\mathrm{I}}{R}:Al:Si=1:3:8$ (instead of $1:4:10$ previously accepted) and writes the formula $\overset{\mathrm{I}}{R}_2AlSi_4O_{12}$, where $\overset{\mathrm{I}}{R}=Li$ and Na in the ratio of 15 : 1.

The composition of petalite is also discussed and the conclusion reached that is expressed by the formula $\overset{\mathrm{I}}{R}_2AlSi_{10}O_{24}$, and the opinion is advanced that petalite bears the same relation in composition to spodumene that albite does to anorthite. E. S. D.

13. *Cacoxenite from Lake Superior.* (Communicated).—Mr. E. CLAASSEN of Cleveland has identified cacoxenite on the martite of Lake Superior. It appears in brownish-yellow acicular crystals forming radiating tufts.

14. *A titaniferous Chrysolite.*—M. DAMOUR has described a titaniferous chrysolite from Zermatt, Switzerland. It has a red color, similar to that of almandine garnet; G.=3·27. An analysis afforded SiO_2 36·14, TiO_2 6·10, MgO 48·31, FeO 6·89, MnO 0·19, ign. 2·23=99·86; this gives almost exactly the required ratio of 1 : 1 for bases to silicon.—(*Bull. Soc. Min. France*, ii, 15.)

15. *On the crystalline system of Pyrostilpnite* (*Fireblende*).—STRENG, in a paper devoted to a thorough crystallographic description of some silver minerals from Chañarcillo, Chili, states that pyrostilpnite (feuerblende) belongs to the orthorhombic, not the monoclinic, system. The conclusion is based both upon the meassured angles and the optical character.—(*Jahrb. Min.*, 1878, 897).

16. *Die Meteoritensammlung der Universität Göttingen*, von C. KLEIN.—The collection of meteorites at Göttingen, according to the recent catalogue of Professor Klein, is one of the great collections of the world, including meteoric stones from 115 distinct falls, and 90 meteoric irons from different localities.

17. *Enstatite rock from South Africa.*—Professor Maskelyne has described a rock from two localities in the Transvaal, South Africa, consisting solely of massive enstatite. This is a kind previously not recognized in lithology, although rocks have been known which, as lherzolyte, contain enstatite as a prominent ingredient.

III. BOTANY AND ZOOLOGY.

1. *Polyembryony, true and false, and its relation to Parthenogenesis.*—Strasburger has an interesting paper, *Ueber Polyembryonie*, in the Zeitschrift für Naturwissenschaft of Jena (1878), which we know as yet only at second hand, chiefly from a notice in the Archives des Sciences Phys. et Nat. of February, 1879.

Strasburger's researches upon the fecundation of the angiospermous Phænogams show that the embryo-sac very seldom produces more than one embryonal vesicle which is fecundated or capable of being fecundated. The single constant exception to this rule, known to him, is that of *Santalum album* which produces two; and one or two Orchids are mentioned in which the embryonal vesicle divides into two, occasionally. True polyembryony must therefore be very rare in Angiosperms. But seeds containing more than one embryo are of common occurrence in oranges, in *Funkia*, *Allium* or *Nothoscordum*, etc. According to Strasburger, all supernumerary embryos in such cases are adventitious, originate outside of the embryo-sac by a kind of prolification in the nucleus, and are not fecundated at all. They appear in the form of minute cellular protuberances, which lengthen by degrees and push into the embryo-sac by a sort of hernia, or pierce their way into it, becoming in the ripe seed veritable embryos, which it is not easy to distinguish from the one resulting from the fecundation of the embryonal vesicle itself. Independent as these adventive embryos are of fecundation, yet Strasburger could not obtain them in *Nothoscordum* when he had extirpated the stamens before an-

esis and prevented access of pollen. But it appears that *Cœlogyne* is just a case of this kind, namely, one in which an adven-e embryo is habitually produced, instead of the normal embryo ich fails from the want of fecundation, the male plant not ing in cultivation. It is understood that this is not a mere erence, but that Strasburger has traced the development of the ibryonal vesicle in the ovule of *Cœlobogyne*, followed by its lure and resorption, and by the independent production of ventive embryos in the manner above described.

This, then, gives an explanation of the long-disputed *parthenonesis* of *Cœlobogyne*, and therefore of the less notable instances. Parthenogenesis, it is then concluded, is only in appearance; it sometimes, and perhaps in all cases, "a prolification of the cleus." Now we should insist that, since the result is "a verible embryo" (equivalent in structure, position of radicle, and imate growth to the true embryo), and not a bud, parthenogens is the just name; that the very interesting and important nclusion attained is that parthenogeny results, not from the velopment of an unfecundated embryonal vesicle, as was supsed, but from a development of other and extraneous cells into embryo; also that it is not very rare, since the adventive supernumerary embryos of various seeds are cases of this par enogeny.

Not the least interesting consideration is, that we have here a anterpart of what De Bary terms *Apogamy*,—instead of an alogue of it. *Apogamy* is a vegetative prolification from what ould normally result in the product of sexual reproduction. *rthenogeny* proves to be the inverse of this, a vegetative production in the ovule of the proper result of sexual reproduction, :: embryo. And finally, we have in these two modes taken gether—what was quite to be expected—a manifest and signifint narrowing of the *hiatus* between vegetative and sexual reproction, which Mr. Darwin may turn to account.

Some applications of this new knowledge may be made. It is ite possible that more embryos than we are aware of may be ventive. Rather more than a year ago we gave an abstract in s Journal* of Mr. Francis Parkman's interesting paper on the bridization of Lilies. It may be remembered that the greater rt of his hybrids exactly reproduced the female parent. The planation which we suggested to him, and which he refers to in his per, was, that those plants were not really hybrids at all, but were m embryos originated without male influence. What then med to us the least improbable explanation, would now appear be the one altogether probable. A. G.

2. *Notes on Euphorbiaceæ.* By GEORGE BENTHAM. (Extr. Jour. an. Society, No. 100, Dec., 1878, vol. xvii. pp. 185–267).—This oughtful essay presents the general views attained to by Mr. ntham on working up the genera of the great order *Euphorbiaceæ* for the ensuing volume of the Genera Plantarum. We need

* The number for February, 1878, p. 151.

not specify any of the results, except to indicate the author's decision in the case of the *Buxeæ.* He does not follow his predecessors, Baillon and J. Mueller, who, much as they differ in other respects, agreed in setting up the order *Buxaceæ,* taking their cue from Agardh, and making much of the dorsal rhaphe. Bentham concludes that this small group, however well defined, ought not in a general view to be regarded as of higher grade than one of the primary divisions, or tribes, of *Euphorbiaceæ.* We are not the less pleased with this that we quite expected it.

A wider interest will be felt in Mr. Bentham's *excursus* on nomenclature, or rather on some questions which the study of *Euphorbiaceæ* brought up, and which some recent discussions have made pertinent. The general laws of nomenclature of our day, and the principles on which they rest, are laid down in the code which was reported by Alphonse DeCandolle to the Paris International Convention, in the year 1867, and, being approved, was published with a commentary in the autumn of that year, and in an English translation early in the following year. The laws, without the commentary, were printed in this Journal for July, 1868. The ten years succeeding have tested, somewhat thoroughly, the questions (nearly all of minor moment) upon which differing usages prevailed; and though one or two points are still mooted, the great majority of phænogamous botanists are coming to be of one mind and practice. But, as Mr. Bentham remarks: "The result has not been quite effectual in checking the ever-increasing spread of confusion in synonymy. Besides the young liberal-minded botanists who scorn to submit to any rule but their own, there are others who differ materially in their interpretation of some of the laws, or who do not perceive that in following too strictly their letter instead of their spirit, they are only adding needlessly to the general disorder. In the application as well as in the interpretation of these rules they do not sufficiently bear in mind two general principles; first, that the object of the Linnæan nomenclature is the ready identification of species, genera, or other groups for study or reference, not the glorification of botanists; and secondly, that changing an established name is very different from giving a new name to a new plant."

It is to the latter point that this most experienced and even-minded botanist addresses himself. "The rule that long-established custom amounts to prescription, and may justify the maintenance of names which form exceptions to those laws which should be strictly adhered to in naming new plants, is unfortunately now frequently ignored. . . . . The law of priority is an excellent one; and when a genus or species has been well defined by an early botanist in a generally accessible work, but has subsequently been neglected, and the plant became known under other names, it is well that the original one should be restored. . . . . On the other hand, it creates nothing but confusion to suppress a generic name, well-characterized and universally adopted by long custom, in favor of a long-forgotten one, vaguely

designated in an obscure work, out of the reach of the great majority of botanists. . . . . The greater number of Necker's genera have been so imperfectly characterized, with so absurd a terminology, that they are quite indeterminable; and his names deserve to be absolutely ignored, except in the very few cases where Jussieu or other early French botanists have succeeded in identifying them, and corrected their characters; but even then it is doubtful whether these names should not bear the date of the correction, rather than of the original work. Adanson's "Familles," with all the inconveniences of its form and absurd orthography, is much more scientific, and many of his genera are well defined, and have therefore been properly adopted." . . . .

Let us here interject a practical application. There is an old and well-established genus *Smilacina* of Desfontaines. There is a much older genus *Tovaria* of Ruiz and Pavon, founded in 1794, ever since accepted, and without a synonym. Recently Mr. Baker of Kew, finding that Necker has a *Tovaria*, published in 1790, and therefore four years earlier than that of Ruiz and Pavon, takes up this name in place of *Smilacina*, and leaves a new name to be made for the long-established homonymous genus. It will be said that the rule of priority demands the sacrifice, and that the identification of Necker's genus is sure, because the three Linnæan species of *Convallaria* which properly constitute Desfontaines' *Smilacina* are referred to it by name; and that, though it be a case of *summum jus summa injuria*, the injurious consequence is a necessity. But Mr. Bentham's characterization of Necker's work applies even to this instance. Twice over Necker's *Tovaria* is described as having a perianth of five sepals, and the berry is said to be one-celled. Desfontaines' *Smilacina*, on the other hand, is correctly characterized. Moreover, if we do not include this among those names of Necker which, Mr. Bentham says, "deserve to be absolutely ignored," we may yet find that the law of priority has another claim on it. In 1763 a much better botanist than Necker, viz: Adanson, founded a genus *Tovara* (essentially the same name as *Tovaria*) on *Polygonum Virginianum* L., which is not unlikely to be taken up as a genus; and the name would supersede Necker's by the same rule that Necker's supersedes Desfontaines' *Smilacina*. All things considered, then, this is a case for the application of the homely but useful rule *Quieta non movere;* and much of Mr. Bentham's pertinent advice may be condensed into this maxim. But there remain nice questions to settle with regard to the names and extent of the liliaceous genus.

"The representing the Greek aspirate by an *h* was generally neglected by early botanists; but now, ever since DeCandolle altered *Elichrysum* into *Helichrysum*, modern purists have insisted upon inserting the *h* in all cases; and this has been so far acquiesced in that it is difficult now to object to it, though it has the effect of removing so many generic names to a distant part of all indexes, alphabetical catalogues, etc. Admitting the propriety of adding the aspirate in new names, I had long declined

to alter old names on this account; now, however, I find myself compelled to follow the current." Which is, on the whole, regretable, especially as Alph. DeCandolle would hold out with him. See the latter's comment on his Article 66, in which the remark is dropped that, "we do not see why we should be more rigorous than the Greeks themselves." Oddly enough, these same writers who must supply the aspirate to the *e* omit it from the *r*, and write *rachis* and *raphe*, instead of *rhachis* and *rhaphe*,—which is exasperating to lovers of uniformity.

It is unnecessary here to cite Mr. Bentham's appropriate illustration of the indivisibility of the two-worded name of a plant. The proper apprehension of this, and of the paramount rule that no *unnecessary* new names should be given to old plants, will go far to rid the science of a principal remaining ambiguity in nomenclature. For it clearly follows that when a plant has a rightful name under its proper genus, the specific half of it is not to be changed because of any earlier specific name under some other genus, to which the plant does not belong. A. G.

3. *Journal of a Tour in Marocco and the Great Atlas.* By JOSEPH DALTON HOOKER, K.C.S.I., etc., and JOHN BALL, F.R.S., etc. A brief notice of the geological appendix in this work is given on page 332. We add here a few words on the botanical results. Sir Joseph Hooker contributes an article on some of the economic plants; the most important portion of which relates to the Argan tree, the natural and economical history of which is now pretty well known. The narrative contains a wood-cut figure of a group of old Argan trees, in which goats are seen high up among the spreading branches, feeding upon the fruit. Of higher scientific interest is the comparison of the Canarian flora with the Maroccan (of which we cannot here undertake an abstract); also the comparison of the Atlas flora with that of the mountains of Grenada, and of northern Europe. So far as is yet known, the north European or Germanic character largely preponderates in it, yet absolutely without alpine representatives. These last probably exist, but at elevations which have not yet been reached. It was a trying experience to have surmounted a pass of the Great Atlas range, only to encounter a snow-storm, and to be obliged to turn back without reaching the higher crests so near at hand. Mr. Ball has worked up the botanical results technically and systematically in his *Spicilegium Floræ Maroccanæ*, which fills nearly 500 pages of the sixteenth volume of the Journal of the Linnean Society, and is illustrated by twenty plates.

This is a very important publication, on account of the care, labor, expense, and critical investigation which are bestowed upon it, not to speak of the beauty and perfection of the specimens; and the associated authors should receive the best thanks of botanists. A. G.

4. *Eaton's Ferns of North America.*—We are not sure that we have noticed the later issues of this work, so important to all fern-people and botanists. But, in any case, we must make a note of

arts 12 and 13, a double number, which has just come to hand, ie plates are so excellent. As to the letter-press, this is always tisfactory. *Aspidium acrostichoides* is well represented, and ell colored. The same would be said of *Pteris aquilina*, were it ot that the frond looks diminutive. The three *Asplenia* make a ne plate. But the figure of *A. parvulum* is stiff: we never saw growing bolt upright, and the difference in size between this id the other two is not made sufficiently manifest. A somewhat ore northern range must be assigned to this species. We found rather common in the mountains of the southern part of Virinia, as well as in North Carolina. *Adiantum Capillus-Veneris*, ie subject of the next plate, and which is luxuriantly delineated, is just now come in from the same region in Virginia,—a disovery by Mr. Shriver. *A. emarginatum* would have been perctly presented if the green were brighter and lucid. The three pecies of *Notholæna* make an admirable plate. A. G.

5. *Algæ Amer. Bor. Exsiccatæ;* by FARLOW, ANDERSON & ATON, *Fasc.* III.—The third Fasciculus of this distribution of orth American Algæ has just been issued. It consists of only iirty specimens, covering twenty-nine species and one variety. ut as most of the species are large plants, the paper used is of the lio size of most American herbariums. Twenty of the Algæ re of the black or olive-green series, and the other nine are lorideæ. Among the rarer kinds are *Sargassum pterpleuron*, om Florida, *Postelsia palmæformis*, *Pterygophora Californica*, *Dictyoneuron* and *Nereocystis*, from the Pacific Coast, and *Saccoiza dermatodea*, from the coast of Maine. The Florideæ embrace everal of the large *Gigartinas* of the Pacific shore, and three or our of those very puzzling forms of *Callophyllis*, which have so ong been an unsolved riddle to the students of this class of lants. Dr. Farlow, who has done nearly all the work of identication, still hesitates to acknowledge the presence of the Europan *Callophyllis laciniata* on the coast of California; but then e has named two new species of the genus, No. 127, *C. furcata*, nd No. 129, *C. gracilarioides*.

6. *On the Black Mildew of Walls.*—Professor LEIDY remarked iat in the number of "Hardwicke's Science Gossip" for August, resented this evening, there is an article by Professor Paley entled, "Is the Blackness on St. Paul's merely the effect of moke?" According to the author, the blackness is mainly due the growth of a hitherto undescribed lichen, which appears to ourish on limestone and in situations unaffected by the direct ays of the sun. Professor Leidy continued, that his attention ad been called a number of years ago to a similar black appearnce on the brick walls and granite work of houses in narrow iaded streets, especially in the vicinity of the Delaware River. Noticing a similar blackness on the bricks above the windows of brewery, from which there was a constant escape of watery apor, in a more central portion of the city, he was led to suspect iat it was of a vegetable nature. On examination, the black

mildew proved to be an alga, closely allied to what he supposed to be the *Protococcus viridis*, which gives the bright green color to the trunks of trees, fences, and walls, mostly on the more shaded and northern side, everywhere in our vicinity. It probably may be the same plant in a different state, but, until proved to be so, may be distinguished by the name of *Protococcus lugubris*. It consists of minute round or oval cells, from 0·006 to 0·009^{mm} in diameter, isolated or in pairs or in groups of four, the result of division; or it occurs in short irregular chains of four or more cells up to a dozen, occasionally with a lateral offset of two or more cells. The cells by transmitted light appear of a brownish or olive-brownish hue. In mass to the naked eye the alga appears as an intensely black powder.—*Proc. Acad. Nat. Sci. Philad.*, Sept. 3, 1878.

7. *On two Bermuda fishes, mistakenly described as new;* by Dr. A. GÜNTHER.—In the February number of the Annals and Magazine of Natural History, pp. 150–151, is published a paper by Dr. A. Günther, F.R.S., "On two new Species of Fishes from the Bermudas." The species which he names *Gerres Jonesii*, was described by me in this Journal, vol. vii, August, 1874, p. 123, under the name *Diapterus Lefroyi;* that called by him *Belone Jonesii*, was also described by me, under the same name, and dedicated to the same worthy naturalist, in this Journal, vol. xiv, October, 1877, p. 295. The descriptions harmonize in all essential details, and I have myself seen the specimens which were subsequently presented by Mr. Jones to the British Museum, though my own descriptions were drawn up from other specimens collected by myself at nearly the same time and locality.

Smithsonian Institution, Feb. 17, 1879. G. BROWNE GOODE.

8. *Alaska Chitons and Limpets.*—A paper on this subject, by W. H. Dall, giving a synopsis of the genera and notes on the various species with their synonymy, makes a number of the Bulletin of the U. S. National Museum. It is illustrated by four plates, and some wood-cuts, representing the dentition of many of the species. The Bulletin is not yet separated into volumes, and this paper is No. 4 of Mr. Dall's "Scientific Results of the Exploration of Alaska," the first two numbers being in Proc. Philad. Acad., 1876.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the discovery of mineral wax, Ozocerite, in Utah;* by Professor J. S. NEWBERRY. (From a letter to the Editors.)—I have obtained some of the recently discovered ozocerite in Salt Lake City from Professor J. E. Clayton, to whom also I am chiefly indebted for such information as I have in regard to its place and manner of occurrence. He writes me as follows: "The geographical position of the ozocerite deposits is in the Wahsatch Range, on the head waters of the Spanish Fork, east from the south end of Utah Lake. The material has been found saturating

eds of brown and bluish shales, probably of Tertiary age, and in nasses of various dimensions more or less mingled with clay. These shales extend from the San Pete valley in a north-northeast lirection for a distance of fifty or sixty miles, and the width of he area or basin which they occupy is at the middle point about wenty miles. The shale beds richest in paraffine vary in thickness from twenty to sixty feet, but there is no considerable accumulation of that substance on the surface, nor would this be possible, as it would be destroyed by the annual fires which weep the country. I examined portions of this region two years ago for coal, and found in the oil shales a few thin seams, and saw the wax-like exudation in several places, but only in small quantity."

Other parties in Salt Lake informed me that the paraffine itself s sometimes twenty feet thick, and that the quantity is enormous; but Professor Clayton says that such statements are not authorized by any facts which have come under his observation.

In the above remarks I have called the earth wax of Utah ozocerite. As it has been stated to be zietrisikite, I may say that on my return from the west, my son and assistant, Spencer B. Newberry, made a series of careful experiments in my laboratory to determine its true nature, comparing it with the description of these hydrocarbons, and with authentic specimens which I have received directly from Galicia. He found that it had a melting point of 61·5° C., that it was completely soluble in a large volume of boiling ether, and that boiling alcohol extracted from it twenty per cent of a white, wax-like substance. It seems, therefore, to be certainly ozocerite and not zietrisikite; the latter melting at 90° C., and being insoluble in ether.

2. *The American Antiquarian: A Quarterly Journal* devoted to early American History, Ethnology and Archæology, edited by Rev. STEPHEN D. PEET. Cleveland, Ohio. (Brooks, Schinkel & Co.).—The third number of this new Journal was published in January, 1879; among other papers it contains one on native American Architecture, by E. A. Barber, which is illustrated by several figures of Colorado Cliff houses. The Journal is well edited and promises to be of value to all interested in Archæology.

3. *Wanderings in South America, the Northwest of the United States and the Antilles, in the years* 1812, 1816, 1820, 1824; by CHARLES WATERTON, Esq. New edition, edited with biographical introduction and explanatory index, by the Rev. B. G. Wood. 520 pp. 8vo. London, 1879. (Macmillan & Co.).—The volume of "Waterton's Wanderings" was first published in 1825, and since that time it has afforded pleasure and profit to a large number of readers. In the present edition the original account is left unaltered, but to this are added a full and appreciative biography of the author, by the Rev. B. G. Wood, and a valuable Explanatory Index, covering 150 pages, in which information is given in regard to the many unusual animals, birds and trees, mentioned in the body of the work.

4. *A Real Telegraph.*—A new invention of a really practical character, not a mere "paulo post futurum" invention like many we have heard of lately, has just been made by Mr. E. A. Cowper, the well-known mechanical engineer. It is a real telegraphic writing machine. The writer in London moves his pen, and simultaneously at Brighton another pen is moved, as though by a phantom hand, in precisely similar curves and motions. The writer writes in London, the ink marks in Brighton. We have seen this instrument at work, and its marvels are quite as startling as those of the telephone. The pen at the receiving end has all the appearance of being guided by a spirit hand. The apparatus is shortly to be made public before the Society of Telegraph Engineers.—*Nature*, Feb. 6.

5. *The chemical composition and physical properties of Steel Rails.*—Dr. C. B. DUDLEY, Chemist of the Pennsylvania Railroad Company, has made an extended investigation of the relation between the chemical composition of steel rails and their power to withstand wear, and in view of the great practical importance of the subject his results cannot fail to have a high value. Some of his conclusions are:—that high phosphorus is inconsistent with safety; that the silicon should be as low as is consistent with the successful working of the Bessemer process; that the best range of carbon is 0·25 to 0·35 per cent, and of manganese from 0·30 to 0·40 per cent. He also concludes that the wearing power of steel rails does necessarily increase with their greater hardness.—(*Trans. Inst. Min. Engineers*, vol. vii.)

6. *The Meteorologist*, published monthly in the interest of the Science of Meteorology. Vol. i, No. 1, March, 1879, J. M. L. STUMP, editor, Greensburg, Pa. An eight-page journal devoted to meteorology.

7. *The Paleontologist.* No. 3, Jan. 15, 1879, Cincinnati. Contains description of new species of fossils from the Lower and Upper Silurian rocks of Ohio, by U. P. James.

OBITUARY.

Professor GUSTAV LEONHARD, of Heidelberg, died December 27, 1878. He was well known as the author of works on Mineralogy and Geognosy, and as editor with Professer H. B. Geinitz, of the Neues Jahrbuch für Mineralogie, Geologie und Paleontologie.

On the extent and significance of the Wisconsin Kettle Moraine, by T. C. Chamberlain, A.M., State Geologist and Professor of Geology in Beloit College (Trans. Wisc. Academy of Sciences.)

On the Annelida Chætopoda of the Virginian Coast, by H. E. Webster (Transactions of the Albany Institute, vol. ix, January, 1879.)

Apuntes relativos à los Huracanes de las Antillas en Septiembre y Octubre de 1875 y 1876; Discurso leido en la real Academia de Ciencias Medicas, Fisicas y Naturales de la Habana en Sesion del 9 de Septiembre de 1877 y siguientes; par el socio de merito Rdo, P. Benito Viñes, S. J., Director del Observatorio. 25 pp. 8vo. Havana, 1878.

The Local Geology of Davenport, Iowa; by Rev. W. H. Barris (Davenport Academy Natural Sciences, Sept., 1876). New Fossils from the Corniferous Formation at Davenport (ibid., Oct., 1878).

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AMERICAN

RNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

XLI.—*Experiments in Cross-Breeding Plants of the same variety;* by Professor W. J. Beal.

LY in the spring of 1877, the writer received the first of Darwin's book on "The Effects of Cross and Self-ation of Plants." The book seemed to be a most in-re production, one which has not been excelled in impor-o the farmer by any work in this or in any age. But, in rds of the Gardener's Chronicle, "It is certain that these al results will be a long time filtering into the minds of who will eventually profit most by them." If the results valuable, and if it will take a long time to reach the , this "filtering" process cannot begin too soon, nor be tinuously kept before them. The writer lost no time in similar experiments on several of our cultivated plants, es, onions, Indian corn and beans.

riments with Indian corn.—Yellow dent corn was ob- from two men in different portions of Michigan. In one e corn had been kept ten years or more on the same nd in the other case fifteen years or more on the same In both cases the corn was much alike. The two lots were planted in alternate rows in a plot by itself. The one set of rows were all cut off, thus securing a perfect n those stalks. Seed from this cross was saved and l to compare with corn not so crossed. The yield from ssed seed exceeded the yield of that not crossed, as one d and fifty-three (153) exceeds one hundred (100).

ing black wax beans.—There were, as shown in the plat eight short rows two feet apart with the plants finally l on July 10th, to five plants about fifteen inches apart

in the row. The seed for half the rows (alternating) is called "old stock," and was raised in the garden the previous year from seeds which descended from those raised on the place for nine years or more.

The "crossed stock" was obtained as follows: in 1877, some seeds of the same variety of beans were purchased of James Vick. These were planted in a drill evenly mixed with seeds of the old stock. These grew and looked alike, but the flowers were inter-crossed by bees. Seeds of this crop are termed "crossed stock."

On May 31, 1878, fifteen seeds were planted in each of the eight rows. The plants from the crossed seeds were generally much the largest and as will be seen kept green the longest.

In ten days after planting, seeds of the old stock came up in each row as follows: .... 4, 7, 7, 9=27
In ten days the crossed stock came as follows: 12, 10, 6, 11=39
In seventeen days the old stock came as follows: 7, 11, 10, 10=38
" " " crossed " " " 12, 13, 10, 14=49

On July 22, the pods fit for cooking on each plant numbered as follows. The pods on the two lots of plants were about alike in size.

Old stock	36	1	dead	7	13 =	57	
Crossed stock	dead	0	0	41	0 =		41
Old stock	0	0	8	0	11 =	19	
Crossed stock	6	22	34	0	17 =		79
Old stock	30	0	0	0	0 =	30	
Crossed stock	41	37	21	31	0 =		130
Old stock	0	0	0	0	2 =	2	
Crossed stock	16	29	30	26	2 =		103
			Total old stock		=	108	
			Total crossed stock		=	353	

This variety is greatly raised for the purpose of supplying an early crop of beans to eat pods and all while young. The difference will be seen to be over three to one in favor of the crossed stock.

On August 9, the pods fit for cooking or past that condition were as follows:

Old stock	52	60	dead	43	45 =	200	
Crossed stock	dead	24	16	51	83 =		174
Old stock	38	46	44	71	37 =	236	
Crossed stock	35	52	58	69	62 =		276
Old stock	39	34	30	47	87 =	237	
Crossed stock	63	48	11	66	61 =		249
Old stock	38	46	54	33	39 =	210	
Crossed stock	38	90	52	88	81 =		340
			Total old stock		=	883	
			Total crossed stock		=	1048	

On or before September 16, all were harvested. The pods on each plant numbered as follows:

Old stock	60	62	dead	45	39 =	206	
Crossed stock	dead	160	54	29	139 =		382
Old stock	45	48	36*	71	37 =	237	
Crossed stock	36	145	91	72	51 =		395
Old stock	45	35	37	38	35† =	190	
Crossed stock	103	68	55	128	75 =		429
Old stock	30	39	48	28	40 =	185	
Crossed stock	136	159	58	172	128 =		653
			Total old stock		=	818	
			Total cross stock		=	1859	

On comparing the table for August 9th, with that for September 16, it will be seen that some plants of the old stock had lost part of their fruit. This was on account of the decay of 101 pods. The table also shows that two branches were broken and had died before maturing. These contained 73 pods.

Adding 101 and 73 to 818, we have 992 pods of the old, against 1859 of the crossed. In harvesting, all those pods badly damaged were rejected. The beans of the old stock weighed 29·77 ounces avoirdupois, those of the crossed stock weighed 70·33 ounces avoirdupois, or nearly in the proportion of 100 to 236.

The difference would be a little less, if we allow for the broken plants and decayed pods on the old stock. One plant of the old and one plant of the crossed stock died early and produced no fruit.

Six lots of 50 beans each, were taken at random from the old stock and weighed as follows:

50 seeds	281 grains.	50 seeds	260 grains.
50 seeds	262 grains.	50 seeds	259 grains.
50 seeds	270 grains.	50 seeds	284 grains.
	Total, 1,616 grains.		Average, 269⅓ grains.

The same number of seeds were taken from the crossed stock and weighed as follows:

50 seeds	220 grains.	50 seeds	210 grains.
50 seeds	219 grains.	50 seeds	210 grains.
50 seeds	200 grains.	50 seeds	220 grains.
	Total, 1,279 grains.		Average, 213⅙ grains.

The average weights of an equal number of beans from each stock were nearly as 100 to 79 in favor of the *old* stock.

Agricultural College, Lansing, Michigan.

* This plant contained a dead branch with 21 immature pods.

† This plant contained a dead branch with 52 immature pods.

Art. XLII.—*On the Force of Effective Molecular Action*; by Professor W. A. Norton.

[An abstract of this paper was read before the National Academy of Sciences, April 18, 1878.]

In my paper on the variability of the ultimate molecule, published in the March number of this Journal, I gave the following theoretical expression for the force of effective action of one ultimate molecule of a body on another contiguous to it, deduced from certain fundamental conceptions which were succinctly stated:

$$F=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2}-\frac{m}{x^2}, \tag{1}$$

in which x denotes the distance between the electric envelopes of the contiguous molecules; r the distance between the center of emanation of the attractive force, f, represented by the first term, and that of the repulsion f', represented by the second term; n the coefficient of the attraction f, and m that of the repulsion f'. The expression has been simplified by making one or two assumptions that do not strictly accord with fact, but which can occasion no material error in the general discussion now proposed; as will be shown on another occasion.

If we put $x=ur$, $\frac{n}{m}=k$, and $\frac{m}{r^2}=p$, it becomes

$$F=\left(\frac{k(3+2u)}{(1+u)^2(2+u)^2}-\frac{1}{u^2}\right)p. \tag{2}$$

If this be a true theoretical expression for the force of effective molecular action, it should comprise the essential mechanical theory of solids, liquids, and gases, as well as the special mechanical features of individual substances; and should successfully withstand all the quantitative and qualitative tests that can be applied to it. I propose now to give the result of the application of a number of such tests; and to show that the characteristic features and laws of the three different states of aggregation are deducible from it.

Theory indicates that in the comparison of different solids, liquids, or gases, among themselves, at the same temperature, $p\left(=\frac{m}{r^2}\right)$ may be regarded as constant. In fact we shall for the present assume that both m and r, as well as p, are constant for substances in the same state of aggregation, when the temperature is the same. Upon this assumption one substance will differ from another, in its essential molecular condition, only in the value of k, that is of the ratio $\frac{n}{m}$ of the coefficients of the

attractive and repulsive forces f and f'. I have made a series of calculations of the values of F for various assigned values of x, answering to a number of different values attributed to k. Each set of calculations, if graphically represented, will give a curve that may be termed a *curve of effective molecular action.* It will represent to the eye the essential mechanical features of a body for which the assumed value of k obtains.

1.

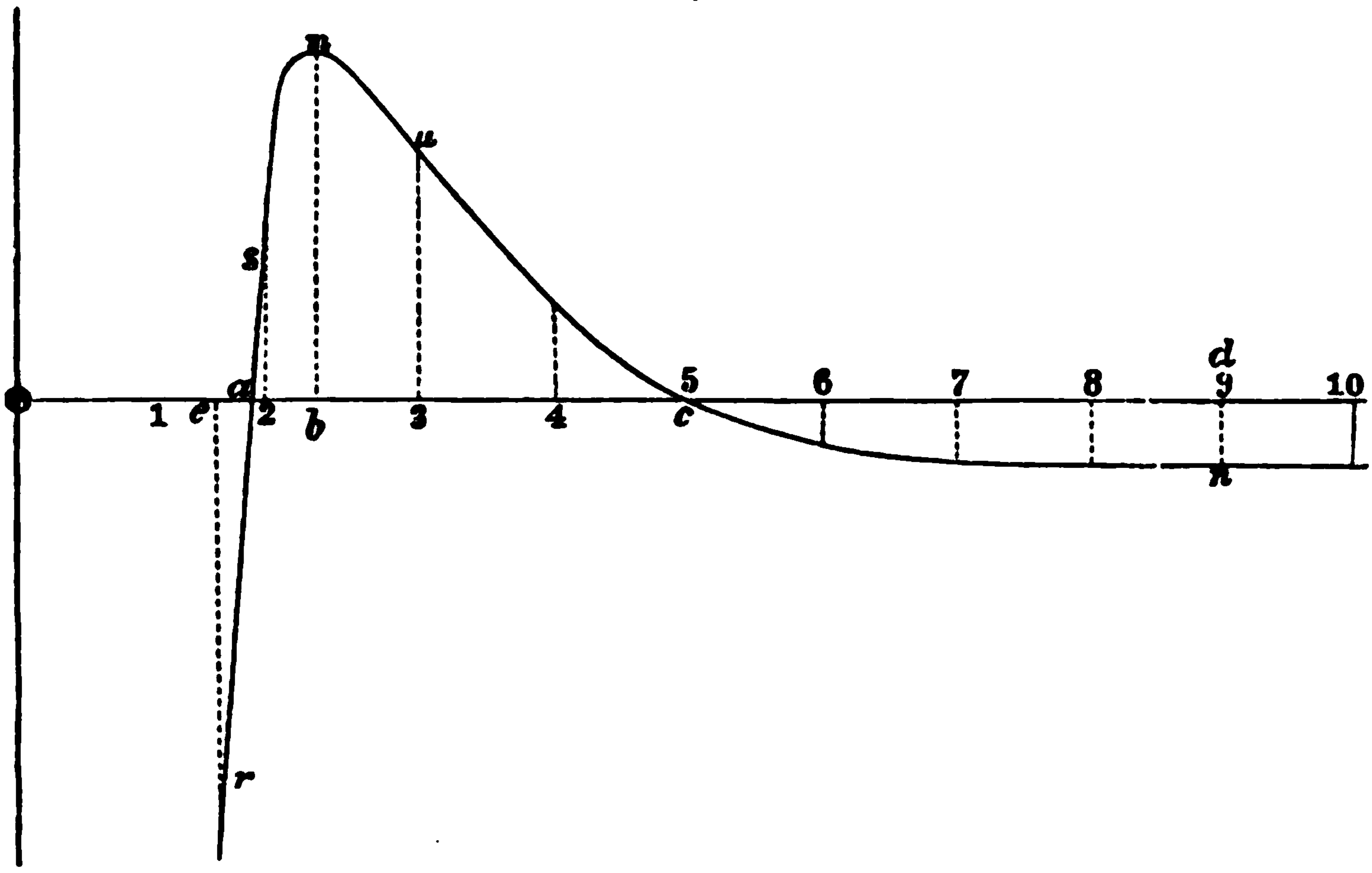
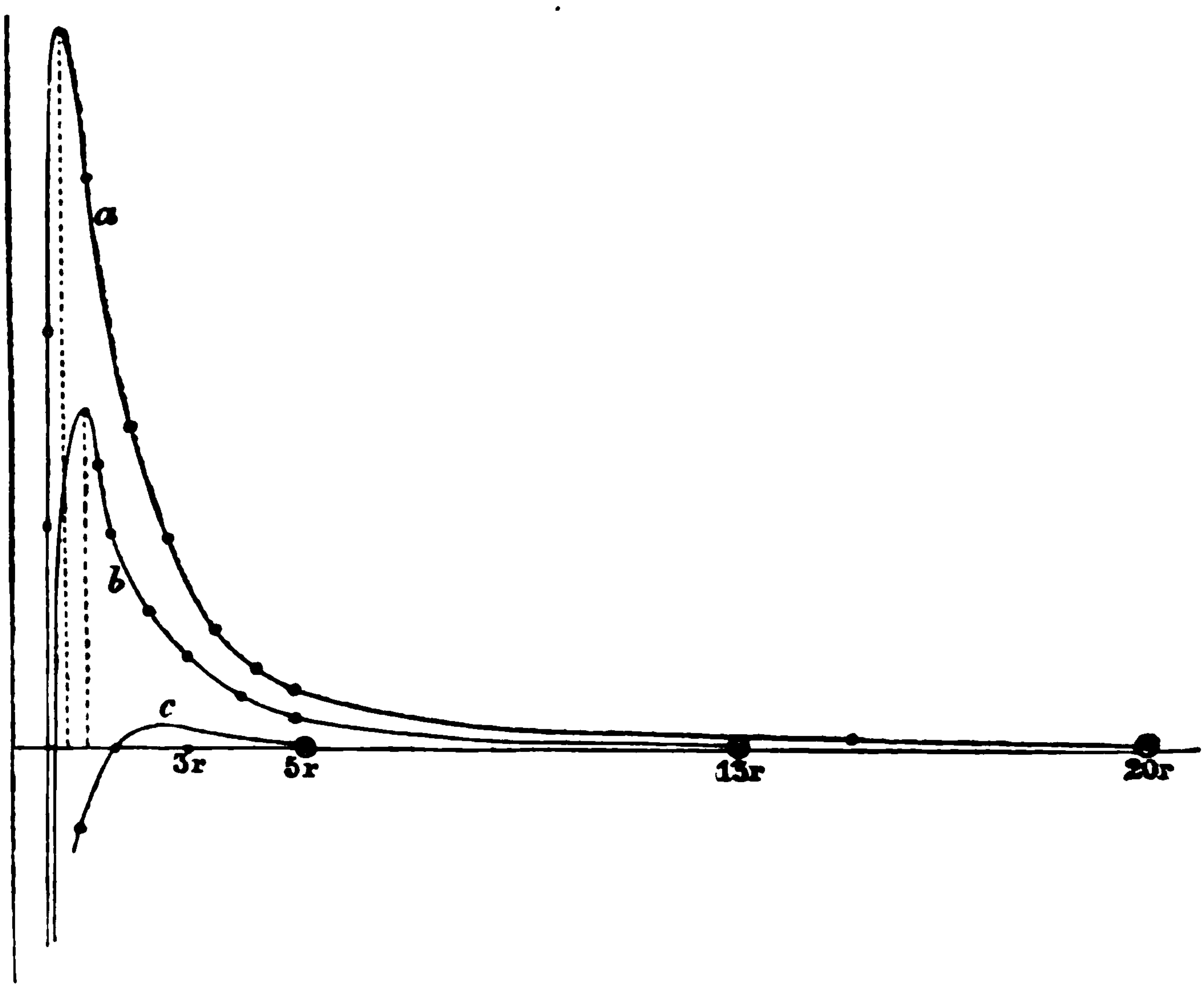


Fig. 1 is such a curve answering to $k = 5{\cdot}428$. In Fig. 2, curve c, the same curve is shown on a smaller scale (both horizontal and vertical). Curve a in this figure answers to $k = 12{\cdot}41$, and curve b answers to $k = 9{\cdot}44$. Fig. 1 may be taken as a type curve exhibiting the features common to the special curves. The positive ordinates indicate comparative values of an effective attractive force in multiples of p, answering to certain distances x expressed in multiples of r; and the negative ordinates indicate values of an effective repulsive force obtaining at other distances x. The distance Oa, between molecular envelopes, at which the effective force is zero, is that which obtains when no external force of stress is in operation. It may be called the *neutral distance.* At all less distances, x, as Oe, that may supervene when a compressive stress is applied to the body, the effective force, er, is repulsive. When a tensile stress is in operation, increasing the distance x, the effective force, as $2s$, becomes attractive, and increases in intensity to the maximum value bm, at the moment of rupture. At greater distances, as $O3$, the effective attraction falls off; and passes into a repulsion when the distance becomes greater than Oc. This repulsion increases with the distance to a maximum dn, and then diminishes continually to an indefinite dis-

tance. This effective repulsion, operating beyond the sphere of the effective attraction, manifests itself as a force of resistance in the contact of bodies. A glance at the curves, (*a*), (*b*), (*c*) in fig. 2, will show that the neutral distance, *Oa*, (see type curve, fig. 1), and the distance, *Ob*, answering to the maximum attractive ordinate, diminish, in multiples of *r*, as *k* increases; and that on the other hand, *Oc* and *Od* increase as *k* increases. The maximum attractive ordinate increases, in terms of *p*, as *k* increases, but the maximum repulsive ordinate augments as *k* diminishes.

2.



The special calculations I have made answer to various assumed values of the ratio *k*, ranging from 0 to 20. I find that when this ratio exceeds 4·934, the effective force will be attractive over a certain range of distance, and thus that a portion of the representative curve will lie above the axis x, as in the curves shown in fig. 2; and that when this ratio is less than 4·934, the effective action will be repulsive at all molecular distances, and therefore that the curve will lie wholly below the axis, x, as in fig. 3. We must, therefore, conclude that for all solids and liquids, *k* must exceed 4·934.

The absorption of the pulses of heat by the molecular envelopes of a body tends to expand these envelopes, and at the same time to augment the coefficient of repulsion, *m*. Heat, therefore, tends to diminish the ratio *k*, and so to depress the curve of effective molecular action. When by the continued access of heat, this ratio is brought to a certain small value

somewhat greater than 4·934, the molecules are in general brought into a certain condition answering to the liquid state, and liquefaction ensues. When, by a still further rise of temperature k equals 4·934, the liquid has reached the boiling point in vacuo. The curve of effective molecular action is now that shown in fig. 3 for $k=4·93$, and the distance between the molecular envelopes, is 2·84 r.

All special curves, answering to particular solids or liquids, and so to values of k greater than 4·934, have certain common features, which should correspond to properties that have been recognized as belonging to all substances in the solid or liquid state. (1.) One of these is that the curves differ little from a right line at the neutral point a (fig. 1). This corresponds, graphically, to the well known law of molecular displacement, that the effective resistance developed is, for small displacements, porportional to the displacement. The ratio of the effective force $2s$, to the displacement $a2$, may be taken as the measure of the coefficient of elasticity, in considering the comparative values of this coefficient answering to varying amounts of tensile stress, and so to various degrees of molecular displacement. As it appears that this ratio is nearly constant, within small limits, the coefficient of elasticity as experimentally determined, should be nearly constant within such limits ; which is a well-known general fact.

(2.) An examination of the curves will serve to show—what is a conspicuous result of the discussion of the equation—that as the tensile stress increases, the coefficient of elasticity as measured by the ratio just stated, should diminish slowly at first and then more rapidly. Experiment has established that in general the coefficient of elasticity of a material varies after this manner. But to make the test more decisive, I have made a series of detailed comparisons of the theoretical with experimental results. It appears that for all values of k ranging from 7·576 to 20 (which, as will hereafter appear, may be regarded as including all the more tenacious solids) the law of variation of the molecular ratio, $\frac{s2}{a2}$ (fig. 1); from the point a to m (i. e. from zero of stress to the point of rupture) is sensibly the same. Thus at the point m, answering to rupture, this ratio becomes reduced to 0·303 of its value at the neutral point, a, when $k=20$; to 0·301 when $k=12·41$; and to 0·316, when $k=7·576$; and the correspondence is equally close at points intermediate between a and m. I have computed the comparative values of the ratio $\frac{s2}{a2}$, for eighteen supposed values of the displacement, $a2$, and compared this scale of computed values,—which, as we have just seen, should answer to any

of the more tenacious materials—with a corresponding series of experimental values of the coefficient of elasticity for bars of cast iron, wrought iron, steel and oak; with the following results. For a bar of cast iron, experimented on by Captain Rodman (U. S. Army), the correspondence is very close. The greatest ratio of error does not exceed $\frac{1}{15}$. For five bars of wrought iron taken for comparison, the correspondence proves tolerably close up to a stress equal to half the tenacity; but at the higher ratios of stress, the coefficient of elasticity diminishes much more rapidly than the theory calls for. For the cast steel bar taken, the coefficient of elasticity is greater than at the neutral point and materially greater than the corresponding molecular ratio, until near the point of rupture, where the two become nearly equal ($\frac{3}{15}$). Several bars of oak examined proved to be in the same category with the cast steel, except that the coefficient ratio at the point of rupture was reduced to from $\frac{6}{15}$ to $\frac{9}{15}$ instead of $\frac{3}{15}$. Four bars of blister steel examined present a case just the reverse of that of the cast steel bar; the coefficient ratios are at all stresses less than the corresponding molecular ratios. In the cases cited the correspondences between the theoretical and the experimental results are sufficient to lend support to the theory; but the discrepancies noticed can only be reconciled with it by admitting that some modifying causes are in operation which tend to produce abnormal deviations from the theoretical results obtained from our formula. Now, as a matter of fact, such modifying causes are known to exist. We have already seen that the ultimate molecule is variable both in its dimensions and its forces, under the operation of varying forces of stress; that k is liable to variation, and hence that the values of F' for the same values of x may change, and the molecular curve shift its position and rise or fall according as k increases under the stress or diminishes. As for the actual tendency of a tensile stress, it is immediately to draw the molecular envelopes farther away from their central atoms. It should thus enlarge the effective molecules, and so by increasing the distance between their centers tend to diminish the coefficient of elasticity. But the enlargement of the envelopes should also tend to alter the value of n; and it appears, on a careful investigation of the diverse possible mechanical conditions of the envelopes, that n may either be increased or diminished, and so the value of k become either greater or less. These incidental effects of forces of stress are adequate to the production of all the deviations, under consideration, from the normal molecular condition represented by the formula or by an unvarying curve; except the very large deviations noticed in the case of the wrought iron bars, when the stress amounted to a large fraction of the breaking weight, which may be reasonably ascribed to a flow of the molecules.

(3.) The distance ab, (fig. 1) between the neutral point and ıe point of rupture increases from $0{\cdot}302r$ for $k=20$, to $0{\cdot}60r$ ›r $k=5{\cdot}428$. This is about its maximum value. From this alue of k to the ratio $4{\cdot}934$ it decreases from $0{\cdot}60r$ to zero. [ow r is the distance between the centers of attraction and ›pulsion, both of which lie within the molecular envelope. It ı therefore a small fraction of the radius of the outer surface of ıe envelope, or outer surface of the effective molecule, and a ıuch smaller fraction of the distance between the centers of ›ntiguous molecules. We should then expect, on theoretical rounds, that when a bar suffers rupture under a tensile stress, ıe elongation would be a small fraction of its length. This is ell known to be generally true for the more tenacious mate- als (e. g. the metals and different varieties of wood). India rub- er is a striking exception. Its great extensibility is probably ue to a great expansibility of its molecular envelopes, under tensile stress. The unequal extensibility of different quali- es of wrought iron, also finds its theoretical explanation in an nequal expansibility of molecular envelopes, with the attend- nt variations in the molecular curve.

(4.) The ordinates of the portion ra of the molecular curve ›present the molecular resistance developed by a compressive ress. These increase (as they should do) without limit, as ıe distance Oe between the molecules diminishes. When rup- ıre occurs under a compressive stress, it is because the molec- lar actions developed in directions oblique to the line of thrust ıduce a tensile strain at right angles to this line, and a shear- ıg strain in oblique directions, the resistance to one or the her of which is overcome. The distance Oa is not the limit the possible diminution in the distance between the centers contiguous molecules, since the act of compression will com- ess their envelopes, and so diminish the size of the effective olecules.

(5.) The ordinates of the portion mc of the molecular curve present the effective attractions that come into operation dur- g the act of rupture. That the rupture may be completed, a ›ntinued molecular strain must be exerted at least as great at ch distance of separation, $O3$, as the effective resistance presented by the ordinate $3u$ at that distance. When the dis- nce has increased to Oc, an effective repulsion supervenes, ıd the separation becomes complete.

Beyond d the curve represents the force of contact resist- ce. To test this portion of the curve, I undertook in 1876, determine experimentally the laws of variation of this force. ›r this purpose the diminutions of contact distance produced varying increments of pressure, under varying conditions ith regard to the nature, condition, and extent of the surfaces

in contact, were determined. The following are the general results obtained.*

(1.) The diminutions of contact distance are very nearly the same, for the same increments of pressure, whatever is the nature or condition of the surfaces in contact.

(2.) They are very nearly independent of the extent of the surface of contact.

(3.) The diminution of distance for a given increment of pressure (say 1 oz.), is nearly inversely proportional to the pressure.

Now, in correspondence with the first of these laws, it appears that at considerable distances beyond that, *Od* (fig. 1) of the maximum repulsion the curves answering to different values of k, and therefore to different materials, approach very near to each other, and beyond $100r$ are very nearly coincident, and have nearly the same inclination to the axis of x. This results from the fact that the attractive term in the formula for the effective force becomes at such distances very small, in comparison with the repulsive term which has the same value for different materials when the temperature is the same. To the same small diminution of distance should then correspond very nearly the same increment of the repulsive ordinate, for the molecular curve of each substance.

The second law follows as a consequence from the third.

As for the third law, it is to be observed that at the contact distances that obtained in the experiments, which must have been much greater than that, *Od*, answering to the maximum repulsive ordinate *dn*, the first term in equation (1), (p. 346) nearly vanishes, and so the effective repulsion (R) expressed by $R=\frac{m}{x^2}$, is nearly inversely proportional to the square of x. Theoretically then, the diminution of distance (dx) for small increments of the repulsion (dR) should be inversely proportional to $R^{\frac{3}{2}}$, or nearly so, instead of inversely proportional to R, as experiment showed. Here, as in previous cases, the discrepancy may reasonably be attributed to the compression of molecular envelopes that must attend the contact pressure; since such compression should increase the value of k, bring the repulsive portion *cn*, etc., (fig. 1) of the curve of effective molecular action nearer the axis *Ocd*, and so cause dx to decrease according to a less rapid law than would obtain if k and the corresponding curve remained constantly the same (which is represented by $\frac{1}{R^{\frac{3}{2}}}$.) In confirmation of this explanation it may be added that a change in the mechanical condition of the contact molecules,

* See this Journal, June, 1876.

during contact pressure, correspondent to this theoretical interpretation, was directly revealed by the experiments.

The experiments alluded to, besides revealing the laws of variation of the contact repulsion, showed that it was a force in operation beyond the range, Oc, of the effective molecular attraction, since no evidence of an attraction was obtained. They showed also that the increments of this force, attendant on the observed diminutions of molecular distance, were many times less than the increments of repulsion attendant on equal diminutions in the distance between the internal molecules of a body; in accordance with the indications of the molecular curve.

It will probably occur to the reader that our formula and curve of effective molecular action, afford no indication of a possible force of adhesive attraction, such as often manifests itself in the contact of surfaces. This defect results from the fact that the formula involves a supposition which is not strictly true in cases of contact. The more comprehensive formula is:

$$f=\frac{n}{(r+x)^2}-\frac{n'}{(2r+x)^2}-\frac{m}{x^2};$$

and equation (1) is obtained by supposing $n'=n$. This equality may not strictly exist in the contact of bodies, and n' may be less than n. I find that a slight excess of n above n' suffices to give an effective attraction for a certain range of values of x, for which f is repulsive according to equation (1). This case would be graphically represented by an upward inflection of the repulsive portion of the curve (fig. 1), bringing a portion of it above the axis of x. The attraction thus orginating should vary in its intensity at a given distance with the pressure, or molecular distance at contact, (i. e. graphically, the inflection of the curve should change); and recent experiments have shown this to be an essential feature of it, since it appears that pieces of plate glass in contact may be separated by the continuous exertion of a force ever so small.

I have now examined the general features of the typical molecular curve for solids, and shown that they represent diverse general mechanical properties of solids that have been experimentally ascertained. Let us now endeavor to subject the molecular formula (equation 2) to the test of comparison with experimental determinations of the coefficients of elasticity and tenacities of special substances. The direct means of accomplishing this would be to determine, if possible, the value of the ratio k for each material, and so obtain a series of definite expressions, or corresponding molecular curves, answering to the materials considered. But the value of k for a given substance is, from the nature of the case, incapable of direct deter-

mination. The only practicable method of proceeding is to assume, under the guidance of any intimations that may be obtained, a value of k for some substance, say wrought iron, taken as a standard of comparison; then the ratio which the coefficient of elasticity of any other material bears to that of wrought iron, will make known the value of its molecular ratio $\frac{2s}{a2}$ (fig. 1) at the neutral point, as compared with that of iron, and from this we may derive the comparative molecular curve for the material considered. The ratio of the maximum ordinate of this curve to that of the standard curve for wrought iron, will then make known the ratio of the tenacity of the material to that of wrought iron (account being taken of the comparative number of atoms, or ultimate molecules, of the two materials, in a unit of volume) and so enable us to compute theoretically its tenacity from the known tenacity of wrought iron. This computed value may then be compared with the tenacity as experimentally determined. In the prosecution of this inquiry, I assumed as the value of k for wrought iron, 12·41; taking for the coefficient of elasticity (E) 25,000,000 lbs., and for the tenacity 55,000 lbs. per square inch. The molecular curve for wrought iron would then be that shown in fig. 2, curve (a). The following notation and formulas were used in the calculations: N=number of atoms, or ultimate molecules in a unit of volume$=\frac{\text{specific gravity}}{\text{atomic weight}}$; n=number of atoms (ultimate molecules) in unit of length $=\sqrt[3]{N}$; E= coefficient of elasticity; T=tenacity; f=intensity of effective attraction between two contiguous molecules at the neutral distance, developed by an increment of distance, equal to $\frac{1}{100}r$. This, in fig. 1, is represented by the ordinate $2s$ corresponding to the small displacement $a2$. F=max. ordinate of the molecular curve. c, c', and c'' are constants.

$$E=c\frac{fn^2}{n}=cfn. \quad T=c'Fn^2.$$

Neutral distance, $d=\frac{r}{\log(1+100f)+u}$; in which u may be taken =zero for the metals generally and the more tenacious woods, for which k must have a value not widely different from that taken for wrought iron (12·41). For less tenacious materials u has a value increasing as k diminishes. For $k=$ 7·576, its value is 0·05. Its maximum value is $\frac{1}{2\cdot 84}$, and obtains when $f=o$, in which case $k=4\cdot 934$, and the molecular curve falls entirely below the axis x. f is expressed in terms of $\frac{m}{r^2}$ or p, considered as unity (see page 346). For the more

ıacious materials we may take, with but little error, $=\frac{r}{\log 100f}$.

For calculating the maximum ordinate we have the formula, $=\frac{c'}{d^{3\cdot 2}}$.* With these formulæ I have calculated the theoreti-l tenacities of a number of materials. The results are given in e following table, and compared with the tenacities obtained experiment. With most of the materials the experimental terminations of coefficients of elasticity and tenacity used, e known, or there is good reason to believe, answer to the me specimen; but in the cases of zinc, brass, and tin, the coef-ient of elasticity and the tenacity may have been obtained th different specimens.

Material.	Coeff. of Elas., E.	Tenacity. Observed.	Tenacity. Calculated.
·ought Iron	25,000,000 lbs.	55,000 lbs.	
ık	2,214,000 "	15,000 "	14,600 lbs.
cust	1,795,000 "	11,280 "	11,157 "
k	1,311,100 "	8,500 "	8,170 "
›tch Fir	802,800 "	3,520 "	3,586 "
pper	16,447,400 "	36,180 "	36,460 "
ıc Wire	13,680,000 "	22,551 "	27,950 "
ass, cast	9,170,000 "	18,000 "	20,300 "
ı, cast	4,608,000 "	6,650 "	7,820 "
ad	720,000 "	1,824 "	1,870 "

It seems from these results that our molecular formula (equa-›n 2) enables us to compute the comparative tenacities of ma-rials from their comparative coefficients of elasticity, with a ›se approximation to the truth; also that a scale of mo-;ular curves may be deduced from it which serves to repre-nt the comparative mechanical properties of different mate-ıls. The scale obtained rests on the assumption that the ›lecular curve for wrought iron is that answering to $k=$ ·41 (fig. 2) curve (a). But the laws of variation of the neu-ıl distance, d, and the maximum ordinate, F, are so nearly nstant over a wide range of variation in the value of k, and us of the corresponding molecular curve, that the assumed rve for wrought iron might be considerably changed without ıterially impairing the correspondence between the computed d observed tenacities. The exponent of d in the expres-›n for the maximum ordinate, which in the calculations was ꞔen 3·2, varies only from 3·1 to 3·4 over the entire range of lues of k from 20 to 5·4; and the value of u in the expres-

* Each molecule is subject to the action of several molecules, instead of the rest one only, but the entire force taking effect on it is equal to the effective ion of the nearest molecule multiplied by a factor which should be nearly con-nt for different materials.

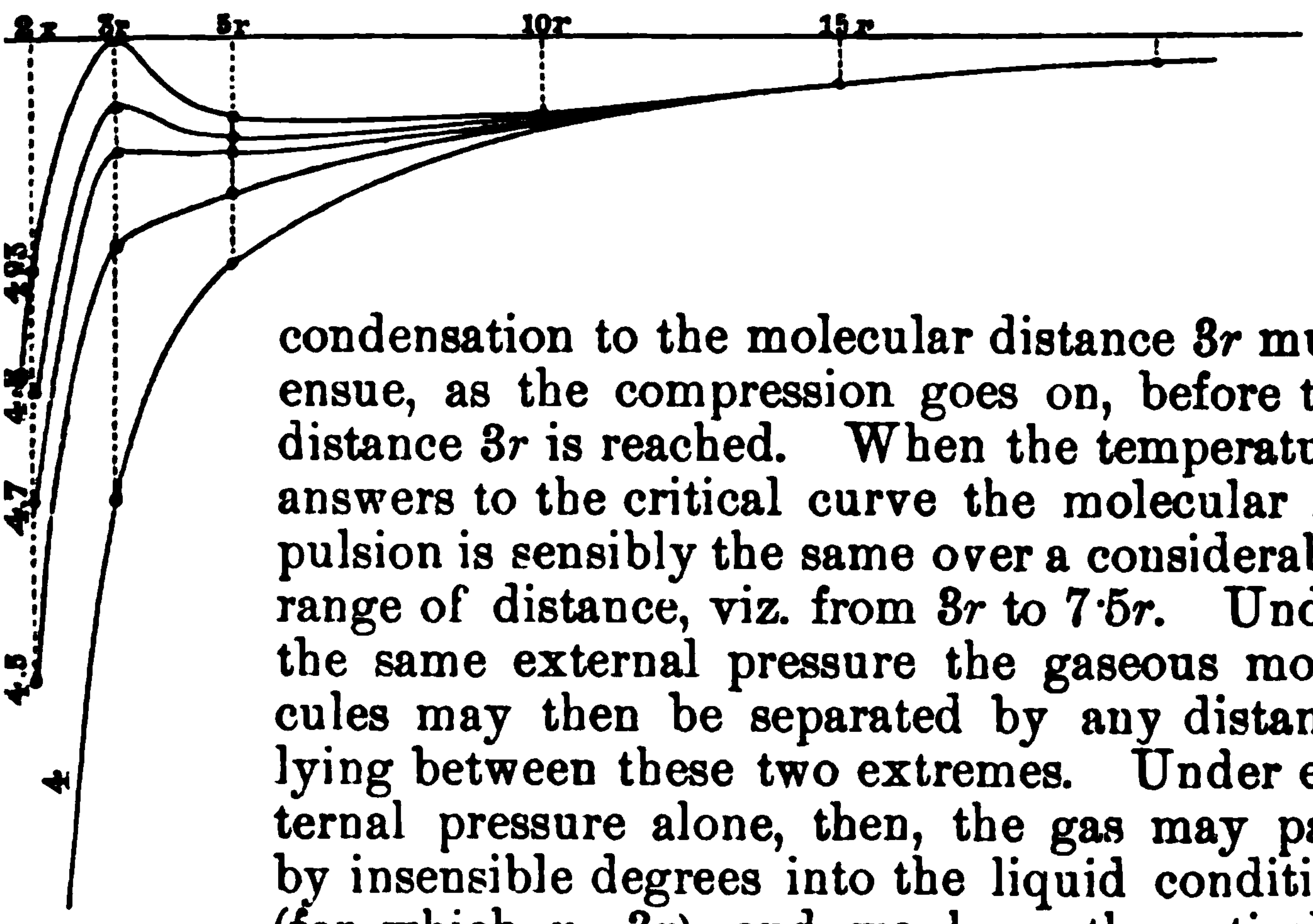
sion for the neutral distance varies only from zero to less than $\frac{1}{3}$.

It is important to remark, in this connection, that the complete molecular theory of the elastic resistance of materials cannot be developed from the single conception that each specimen of every material has its specific formula, or curve of effective molecular action, which remains constantly the same during all the varying conditions and degrees of stress. Thus when two specimens of the same material are compared, certain facts are recognized which require that account should be taken of the varying dimensions and mechanical condition of the molecules when under the influence of the force of stress. For example, the tenacities of two bars of wrought iron, or one bar of iron and another of steel, may be very different, though their coefficients of elasticity, E, may be nearly the same. The theoretical explanation of this fact, is that the molecular envelopes are drawn farther away from the central atoms of the molecules, and as a consequence the ratio k is increased, the molecular curve rises, and thus while the coefficient, E, for small displacements from the neutral distance is but little altered, the maximum ordinate, and so the tenacity, may be largely increased. It may be shown that the liability to this state of things exists with materials having a high value of k. The rise of the "limit of elasticity" as the result of the operation of a tensile stress to certain materials, and the augmentation of the tenacity of wrought iron bars by large tensile strains, as well as by a certain increase of temperature and by the process of thermo-tension, are other consequences of a similar molecular condition. It may be said in general that all the recognized deviations of property from the normal type of unvarying and perfect elasticity, while they must present insuperable obstacles to any molecular theory that does not recognize the "variability of the ultimate molecule," furnish to the present theory the occasion of its achieving one of its most signal triumphs.

Let us now subject the formula to the test of comparison with the laws and mechanical properties of vapors and gases. Upon the general theory the effective mutual actions of contiguous molecules of a vapor, or gas, must be repulsive. The curve of effective action of such a molecule must then lie entirely below the axis x; and hence it must answer to a value of k less than 4·934. Fig. 3 shows a set of theoretical curves answering to various values of k in equation 2, from 4·93 to 4. The vertical scale in this figure is 20 times that in fig. 2. These curves present two distinct varieties; one in which a portion of the curve is concave to the axis, x, and another in which the curve is everywhere

·ex to this axis. These two sets of curves have for their of demarcation a curve in which a considerable portion is llel to the axis. This curve answers to $k=4{\cdot}7$. The first pper set of curves answers to vapors, and to gases when : temperature is such that they can be compressed into a id without further reduction of temperature. The reduc- to a liquid by pressure alone is possible with some gases, sulphurous acid gas, chlorine, carbonic acid, etc.) ordinary temperatures, and continuously up to cer- higher temperatures. At these critical temperatures curve becomes the critical curve just mentioned for :h $k=4{\cdot}7$. Oxygen, hydrogen, etc., belong to a class gases which cannot be condensed into a liquid un- the temperature is much reduced below ordinary tem- tures. For these the smaller values of k obtain. The con- ıation into the liquid form is impossible because the repul- ordinate steadily increases as the molecular distance x inishes. A reduction of temperature diminishes the value n, which is theoretically proportional to the absolute perature, and so increases the value of k and causes the ecular curve to rise. When it is thus brought above the cal curve, for which $k=4{\cdot}7$, it becomes for a certain ınce beyond $3r$ concave upwards, the effective repulsion ns to decrease at a certain distance beyond $3r$, and a sudden

3.



condensation to the molecular distance $3r$ must ensue, as the compression goes on, before the distance $3r$ is reached. When the temperature answers to the critical curve the molecular repulsion is sensibly the same over a considerable range of distance, viz. from $3r$ to $7{\cdot}5r$. Under the same external pressure the gaseous molecules may then be separated by any distance lying between these two extremes. Under external pressure alone, then, the gas may pass by insensible degrees into the liquid condition (for which $x=3r$), and we have theoretically "continuity between the gaseous and liquid states of ter," experimentally realized by Dr. Andrews. The cal temperature for carbonic acid gas, Dr. Andrews found

to be 31° C. At this temperature then the molecular curve for this gas was the curve for which $k=4\cdot7$.

We have already seen that when a liquid reaches its boiling point in vacuo, its molecular curve is just tangent to the axis, x, at the point $x=2\cdot84r$, and that $k=4\cdot934$. When the liquid, say water, is subject to the atmospheric pressure, as the temperature rises above 72° F., (its boiling point in vacuo) and m continually increases, the curve subsides until the molecular repulsion, for $x=3r$, is just on the point of prevailing over the atmospheric pressure. The liquid will then be at its boiling point, 212° F. The slightest increase of heat repulsion will now cause the molecules to recede from each other, since the effective repulsive ordinates augment with the distance, x, and this recess should continue until the repulsive ordinate again becomes equal to the minimum value, that obtained when the recess began. To this tendency to a sudden separation of the molecules over a wide range of distance may be ascribed the agitation of the liquid, called boiling; and the amount of the final separation should fix the ratio of expansion in the passage of the liquid into vapor, at the boiling point. If the liquid boils under a higher pressure than one atmosphere, the access of heat augments the minimum molecular repulsion that obtains at about the distance $3r$, until it is on the point of prevailing over the actual pressure. The curve will now have subsided still more, and the recess of the molecules to the point at which the molecular repulsion becomes the same again, and so the expansion from the liquid to the steam at the higher boiling point and pressure, should be less than before (see fig. 3). It should be observed here, that the process of expansion in the conversion of the liquid into steam consists in part in an expansion of the molecular envelopes, or an enlargement of the effective molecules; and part of the heat lost is expended in thus augmenting the potential energy of the molecules.

When the reverse process occurs, and steam at 212° F. is condensed, the increasing repulsion shown by the curve is largely expended in condensing the molecular envelopes, with an attendant evolution of heat; and thus the process may set in as soon as the external pressure materially exceeds one atmosphere. A reduction of temperature brings on condensation by decreasing the value of m, which has the effect to raise the molecular curve, both by diminishing $p\left(=\frac{m}{r^2}\right)$ the unit in terms of which the repulsions are expressed, and increasing the ratio $k\left(=\frac{n}{m}\right)$.

[To be continued.]

ART. XLIII.—*On the Mineral Locality in Fairfield County, Connecticut, with the description of two additional new species*; by GEORGE J. BRUSH and EDWARD S. DANA. Second paper.

IN the preceding volume of this Journal (July and August, 1878), we published an account of the discovery of a new mineral locality at Branchville, Fairfield County, Connecticut, and gave descriptions of five new minerals, all manganesian phosphates, occurring there. During the autumn following we pushed forward our explorations at the locality with as much vigor as possible, and with tolerable success. We were fortunate in finding a new and independent deposit of the phosphates, and obtained from it a considerable quantity of eosphorite, lithiophilite and a little triploidite, and with them some other species of interest, among which we may mention a series of uranium compounds. The detailed description of these discoveries we shall defer until a third paper, which we hope to publish in another number. In the present paper we propose to give the descriptions of the two additional new species we have identified; one of these we mentioned in our last paper under the name of *fairfieldite*. We add also the results of a new analysis of reddingite, and some further facts in regard to lithiophilite. Both of the new species came from the original material, removed by Mr. Fillow, when the locality was first opened. We have not, as yet, succeeded in finding additional quantities of them. It may not be improper to add that with the return of warm weather we have commenced anew the exploration of the locality in a more thorough manner than before, and we hope to meet with some success.

6. FAIRFIELDITE.

General physical characters.—Fairfieldite occurs usually in massive crystalline aggregates; also rarely in distinct crystals. The structure is foliated to lamellar, some varieties closely resembling selenite; also occasionally in radiating masses consisting of curved foliated or fibrous aggregations; these radiated forms are not unlike stilbite.

The hardness is 3·5, and the specific gravity 3·15. The luster is pearly to sub-adamantine; on the surface of perfect cleavage (*b*) it is highly brilliant. The color is white to pale straw-yellow; the streak is white. Transparent. Brittle.

Two rather distinct varieties have been observed: the first (A) occurs filling cavities in the reddingite, and covering the distinct crystals of this mineral. It is uniformly clear and transparent, and is highly lustrous, showing entire absence of even

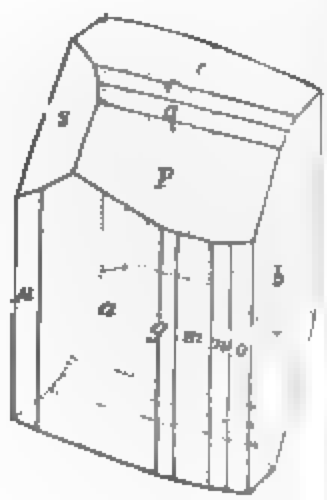
incipient alteration. It is generally foliated to lamellar, although sometimes of a somewhat radiated structure. The second variety (B) occurs in masses of considerable size interpenetrated rather irregularly with quartz, and quite uniformly run through with thin seams and lines of a black manganesian mineral of not very clearly defined character. This mineral is granular in texture, lustrous, is difficultly fusible, and consists for the most part of the hydrated oxides of manganese and iron; but contains also phosphoric acid and traces of lime.

This second variety of fairfieldite is often friable to the touch and lacks something of the brilliant luster of the first variety. It also shows greater difference of structure, passing from the distinct crystals to the massive and radiated form. The identity of these two kinds is shown by the analyses given below. Fairfieldite also occurs in small particles in fillowite (described beyond), and in masses of some size immediately associated with eosphorite, triploidite, and dickinsonite.

Crystalline form.—Indistinct crystals of fairfieldite occur occasionally in cavities in the massive mineral. They are usually composite in character, made up of many individual crystals, interpenetrating each other, and in only an approximately parallel position. On the most favorable crystals the form could be clearly made out, but exact measurements were quite impossible; this is the more to be regretted as the number of variable elements is so large. The cleavage parallel to b (010) is highly perfect; that parallel to a (100) somewhat less so.

The crystals belong to the *Triclinic System*, and the general habit is shown in the adjoining figure. The following supplement angles were accepted as the basis of the calculations.

$a \wedge c$	$100 \wedge 001$	=	88°
$a \wedge b$	$100 \wedge 010$	=	102°
$a \wedge p$	$100 \wedge 111$	=	56° 30′
$c \wedge p$	$001 \wedge 111$	=	33°
$b \wedge p_i$	$010 \wedge 111$	=	78° 30′



From these angles, the lengths and mutual inclinations of the axes were calculated, as follows:—

	c (vert.)	$\bar{b}$	$\breve{a}$
	·7065	3·6757	1·0000 or
	·1976	1·0000	·2797
Also	α ($c \wedge \bar{b}$)	β ($c \wedge \breve{a}$)	γ ($\bar{b} \wedge \breve{a}$)
	102° 9′	94° 33′	77° 20′

The observed planes are as follows:—

c	*O*	001	*s*	$-4\text{-}\breve{4}$	$1\bar{4}1$
b	$i\text{-}\breve{\imath}$	010	*g*	$i\text{-}\bar{\tfrac{3}{2}}'$	320
a	$i\text{-}\bar{\imath}$	100	*m*	I'	110
p	$-1'$	111	*n*	$i\text{-}\breve{\tfrac{3}{2}}'$	230
q	$-\tfrac{1}{2}'$	112	*o*	$i\text{-}\breve{2}'$	120
r	$-\tfrac{1}{3}'$	113	*μ*	*I*	$1\bar{1}0$

The following list includes the principal angles (supplement) r the different planes, calculated from the axial values given bove.

	Calculated.			Measured.
$c \wedge a$	$001 \wedge 100$	=	88°	*88°
$c \wedge b$	$001 \wedge 010$	=	78° 33′	79°
$c \wedge m$	$100 \wedge 110$	=	84° 39′	
$c \wedge p$	$001 \wedge 111$	=	33°	*33°
$c \wedge q$	$001 \wedge 112$	=	18° 31′	19°
$c \wedge r$	$001 \wedge 113$	=	12° 43′	13°
$c \wedge s$	$001 \wedge 1\bar{4}1$	=	53° 34′	
$a \wedge b$	$100 \wedge 110$	=	102°	*102°
$a \wedge g$	$100 \wedge 320$	=	10° 57′	10°
$a \wedge m$	$100 \wedge 110$	=	16° 31′	16° 30′
$a \wedge n$	$100 \wedge 230$	=	24° 40′	25°
$a \wedge o$	$100 \wedge 120$	=	32° 20′	32°
$a \wedge \mu$	$100 \wedge 1\bar{1}0$	=	14° 45′	16°
$a \wedge p$	$100 \wedge 111$	=	56° 30′	*56° 30′
$a \wedge q$	$100 \wedge 112$	=	70° 15′	
$a \wedge r$	$100 \wedge 113$	=	75° 48′	
$a \wedge s$	$100 \wedge 1\bar{4}1$	=	51° 17′	
$b \wedge \mu$	$010 \wedge 1\bar{1}0$	=	116° 45′	
$b \wedge g$	$010 \wedge 320$	=	91° 3′	
$b \wedge m$	$010 \wedge 110$	=	85° 29′	
$b \wedge n$	$010 \wedge 230$	=	77° 20′	
$b \wedge o$	$010 \wedge 120$	=	69° 40′	
$b \wedge p$	$010 \wedge 111$	=	78° 30′	*78° 30′
$b \wedge q$	$010 \wedge 112$	=	78° 2′	78°
$b \wedge r$	$010 \wedge 113$	=	78° 4′	
$b \wedge s$	$010 \wedge 1\bar{4}1$	=	121° 16′	120° 30′
$m \wedge p$	$110 \wedge 111$	=	51° 39′	
$m \wedge q$	$110 \wedge 112$	=	66° 8′	
$m \wedge r$	$110 \wedge 113$	=	71° 56′	

In one case an apparent penetration-twin was observed, the wo crystals crossing one another so that the planes *b* and *a* of he one were parallel respectively to the planes *a* and *b* of the ther. If this coincidence were perfect (exact measurement vas out of the question) and the crystal were really a twin the

twinning-plane must make with *a* (100) an angle of either 51° (toward 010) or 39° (toward $0\bar{1}0$). This condition is equally well satisfied by the plane 270 ($100 \wedge 270 = 51° 4'$), or by $2\bar{7}0$ ($100 \wedge 2\bar{7}0 = 39° 3'$.) As this supposed twinning-plane has so complex a relation to the other planes of the crystal, it is probable that this coincidence is only accidental.

Optical properties.—Minute fragments of fairfieldite parallel to the two cleavage planes were examined in the stauroscope, with the following results:—The planes of light-vibration intersect the cleavage plane *a* (100) in lines which make angles of 40° and 50° respectively with the edge $a \mid b$. One optical axis was visible on the edge of the field in converging light, obviously lying in the vibration-plane making an angle of 50° with the obtuse edge named, and toward that edge.

The cleavage plane parallel to *b* (100) is intersected by the vibration planes in lines making angles of 10° and 80° respectively with the edge $b \mid a$. In this case also an optical axis (the second) is distinctly visible on the outer limit of the field. This serves to fix approximately the position of the bisectrix. As the cleavage fragments examined were less than ¼ mm. in size, any further examination was impossible.

Chemical Composition.—The two varieties of fairfieldite have been analyzed by Mr. S. L. Penfield, with the following results:

	A.	B.
P_2O_5	38·39	39·62
FeO	5·62	7·00
MnO	15·55	12·40
CaO	28·85	30·76
Na_2O	0·73	0·30
K_2O	0·13	....
H_2O	9·98	9·67
Quartz	1·31	0·55
	100·56	100·30

The ratios of the oxides calculated from these analyses are as follows:—

	A.			B.		
P_2O_5	·270	·270	1	·279	·279	1
FeO	·078			·097		
MnO	·219			·175		
CaO	·515	·825	3·06	·549	·826	2·96
Na_2O	·012			·005		
K_2O	·001			---		
H_2O	·554	·554	2·05	·537	·537	1·93

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : 2$ answers to the formula $R_3P_2O_8 + 2$ aq. If here $R = Ca : Mn + Fe = 2 : 1$ and the ratio of $Mn : Fe$ be also $2 : 1$. The formula requires:—

P_2O_5	39·30
FeO	6·64
MnO	13·10
CaO	30·99
H_2O	9·97
	100·00

The fact that the second variety was friable and somewhat deficient in luster suggested an incipient alteration, but the analysis did not confirm this idea. The larger amount of lime afforded in the analysis of this kind is possibly due to admixture of a little apatite, which is often observed with it, and the larger proportion of iron may be due to the fact that this variety could not be entirely freed from the black oxide interpenetrating it.

Pyrognostics.—In the closed tube fairfieldite gives off neutral water, and the assay turns first yellow, then dark brown, and becomes magnetic. In the forceps glows, blackens and fuses quietly at about 4·5 to a dark yellowish-brown mass, coloring the flame pale green, with faint reddish-yellow streaks on the upper edge. Soluble in the fluxes giving reactions for iron and manganese. Fairfieldite is soluble in nitric and hydrochloric acids.

Fairfieldite is named from the county in which the locality occurs.

7. Fillowite.

General physical characters.—Fillowite occurs in granular crystalline masses. By fracture the crystalline grains can be usually separated with ease; they show in most cases merely striated planes of contact, having no crystallographic significance; occasionally, however, isolated but brilliant crystalline planes are observed and rarely a nearly complete crystal. The masses are not infrequently penetrated by distinct prismatic crystals of triploidite; and sometimes they enclose particles of fairfieldite. The outer surfaces are very often coated with a silvery-white radiated mineral, but in so sparing quantities that we have been thus far unable to determine definitely its character. Reddingite is very commonly associated with fillowite, and in many cases it is not easy to distinguish the two minerals.

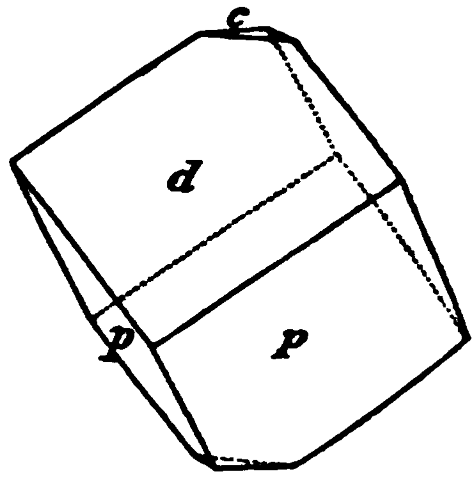
The hardness is 4·5, and the specific gravity in two trials 3·41 and 3·45. The luster is sub-resinous to greasy. The color generally wax-yellow, also yellowish to reddish-brown with a red or green tinge, and rarely almost colorless. Streak white. Transparent to translucent; fracture uneven; brittle.

Crystalline form.—The crystals of fillowite, whose occurrence has already been mentioned, have a marked rhombohedral

aspect. As shown in the figure the three planes, whose several inclinations are almost identical, have their common solid angle replaced by a nearly equilateral triangle. The measurements, however, point to a monoclinic form, and that this is the true explanation is proved by the optical examination. The cleavage is basal, nearly perfect.

The angles (supplement) accepted as the basis for calculation, are as follows:—

$c \wedge p$	$001 \wedge \bar{1}11$	=	58° 40′
$c \wedge d$	$001 \wedge 201$	=	58° 31′
$p \wedge p$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	=	95° 23′



Calculated from these the elements of the crystal are:—

c (vert.)	b	$\breve{a}$	β
·8201	·5779	1·0000 or	89° 51′
1·4190	1·000	1·7303	

The position taken for the crystal is that which exhibits most strikingly its close approximation to the rhombohedral form. If it were desired to make the plane *d* the unit orthodome $\bar{1}01$, then the plane *p* would have the symbols 111 and $1\bar{1}1$, and the elements of the crystal would be:— $\beta = 73° \; 11'$; c (vert.) = 1·1422, b = 0·578, $\breve{a}$ = 1·000.

The observed planes have already been given; they are:—

c 001 *O.* *d* 201 −2-*i*. *p* $\bar{1}11$ 1.

The calculated angles and those measured (on two crystals) are:—

			Calculated.	Measured. (1)	(2)
$c \wedge d$	$001 \wedge 201$	=	58° 31′	*58° 31′	
$c \wedge p$	$001 \wedge \bar{1}11$ $001 \wedge \bar{1}\bar{1}1$	=	58° 40′	*58° 40′ 58° 37′	
$p \wedge p$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	=	95° 23′	*95° 23′	95° 25′
$p \wedge d$	$\bar{1}11 \wedge 201$ $\bar{1}\bar{1}1 \wedge 201$	=	95° 20′	95° 20′ 95° 16′	95° 15′ 95° 18′

Optical properties.—It was found possible to examine small cleavage fragments of fillowite according to the usual methods, and the results served to settle the question of the system, which the measured angles might have left undecided. One vibration-plane intersects the basal plane (cleavage) parallel to the edge $c|d$ and the other is normal to it. Moreover the two optic axes are visible when the Rosenbusch microscope is employed; it was impossible to decide, however, in which plane they lay, since the only sections transparent enough for this examination were destitute of the other crystalline planes.

Chemical properties.—The analyses of fillowite by Mr. S. L. Penfield afforded the following results:—

	I.	II.	Mean.		Ratios.	
P_2O_5	39·06	39·15	39·10	·275	2·75	1
FeO	9·48	9·18	9·33	·129		
MnO	39·48	39·36	39·42	·555		
CaO	undet.	4·08	4·08	·073	8·51	3·09
Na_2O	5·65	5·84	5·74	·092		
Li_2O	·07	·04	·06	·002		
H_2O	1·75	1·56	1·66	·092	·92	0·33
Quartz	0·86	0·90	0·88			
		100·11	100·27			

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : \frac{1}{3}$, corresponds to the formula $3R_3P_2O_8 + H_2O$. If in this formula R = Mn : Fe : Ca : Na_2 = 6 : 1 : 1 : 1 the calculated percentages are:—

P_2O_5	40·19
FeO	6·80
MnO	40·19
CaO	5·28
Na_2O	5·84
H_2O	1·70
	100·00

The very small amount of water present suggests the question as to whether it is really an original constituent of the mineral. This question we have been unable to decide positively; we can only add that of a large number of specimens examined, all, even the most transparent, showed its presence. Moreover, if the water be not essential, the composition of the mineral would be somewhat analogous to triphylite, containing sodium instead of lithium, and the want of correspondence in crystalline form does not favor this idea.

Pyrognostics.—In the closed tube fillowite yields a small amount of water which reacts neutral. B.B. in the forceps colors the flame momentarily pale green, then intensely yellow and fuses with intumescence to a black feebly magnetic globule. Fusibility 1·5. With the fluxes reacts for iron and manganese. Soluble in nitric and hydrochloric acids.

We have named this the *seventh* new manganesian phosphate from this locality, after Mr. A. N. Fillow, of Branchville, Conn., our obligations to whom we have already mentioned in our former paper.

Reddingite.

In our preceding paper we described the new mineral reddingite, and showed that in the habit of its octahedral crystals and in their angles it was closely homœomorphous with scorodite and strengite. In composition, however, it was shown that there was a variation, as follows:—

Scorodite	$FeAs_2O_8+4aq.$
Strengite	$FeP_2O_8+4aq.$
Reddingite	$Mn_3P_2O_8+3aq.$

It is thus seen that reddingite differs from the other species in that the metal is in the protoxide condition, and again since there are only three equivalents of water present. In order to establish beyond all question that this difference was a real one, we have had a second analysis made. The material was selected from another specimen, and as before, was obtained free from all impurities except quartz.

The analyses, made by Mr. H. L. Wells, are given below (A) as also that of Mr. Penfield (B) published in our preceding paper:—

	A I.	A II.	A Excluding Quartz.	B
P_2O_5	33·58	....	35·16	34·52
FeO	7·54	....	7·89	5·43
MnO	41·28	....	43·22	46·29
CaO	0·67	....	·71	0·78
Na_2O	trace	....	....	0·31
H_2O	11·72	11·72	12·27	13·08
Quartz	4·46	4·39		
	99·25		99·25	100·41

The new analysis leads to the formula $Mn_3P_2O_8+3aq$, or the same as that obtained before. The only marked difference between the two results is one which we have found to characterize all the species of the locality, that is, a little variation in the relative amounts of iron and manganese. That the manganese is really in the protoxide condition cannot be questioned for a moment.

Recapitulation.

It seems of some interest to place together the seven new species which the locality has afforded us. We shall hope, at some future time, to offer some remarks in regard to their mutual relations; we can only say here that there is in the facts observed nothing to suggest that any one of the species is a secondary mineral or a product of alteration; all seem to be original minerals of the vein. We have found single hand-specimens which exhibit all of the first four minerals together.

1. EOSPHORITE. Orthorhombic.
   $R_3AlP_2O_{10}, 4H_2O,$ or $AlP_2O_8+2H_2Mn(Fe)O_2+2aq.$
2. TRIPLOIDITE. Monoclinic.
   $R_4P_2O_9, H_2O$ or $Mn_3(Fe_3)P_2O_8+Mn(Fe)(OH)_2$
3. DICKINSONITE. Monoclinic.
   $4(R_3P_2O_8), 3H_2O$ or $4(Mn, Fe, Ca, Na_2)_3P_2O_8+3aq.$

4. LITHIOPHILITE.		Orthorhombic.
$LiMnPO_4$	or	$Li_3PO_4+Mn_3P_2O_8$.
5. REDDINGITE.		Orthorhombic.
$R_3P_2O_8$, $3H_2O$	or	$Mn_3(Fe_3)P_2O_8+3aq$.
6. FAIRFIELDITE.		Triclinic.
$R_3P_2O_8$, $2H_2O$	or	$Ca_2(Mn_3, Fe_3)P_2O_8+2aq$.
7. FILLOWITE.		Monoclinic.
$3(R_3P_2O_8)$, H_2O	or	$3(Mn, Fe, Ca, Na_2)_3P_2O_8+aq$.

Altered Lithiophilite.

In our former paper we called attention to the large amount of black oxidized material rich in lithia which was associated in the first deposit with eosphorite, triploidite and dickinsonite. We stated also, that the occurrence of this black substance induced us to make the deeper exploration which resulted in the discovery of lithiophilite. We have now made a more critical examination of this black mineral, and have found on breaking it up into very small fragments occasional kernels or nuclei, often no larger than a pea, of unaltered lithiophilite. By far the greater part of the black masses, however, have proved to be oxidized to the core. The black material varies considerably in its structure; some specimens retain with great distinctness the cleavage of the original lithiophilite; other fragments break with a conchoidal fracture, while still other specimens form porous, crumbly, loosely aggregated masses. The color of the mineral also varies; it is generally grayish-black to pitch-black; occasionally, however, it has a purple to violet color, the latter being due apparently to a different state of oxidation of the manganese and iron. That this is the case seems to be proved by the fact that the black variety can be made to assume a purple hue by dipping it in hydrochloric acid; the mass so treated becomes at once colored purple externally, and is not to be distinguished from a specimen of the naturally occurring purple mineral. The luster varies from sub-resinous to dull. Hardness 3–4. Specific gravity 3·26–3·40. It is not to be expected that in such an alteration product the chemical composition should be constant. We have had two characteristic specimens analyzed and give the results below. The first was of the cleavable variety, having a nucleus of unaltered lithiophilite, and was analyzed by Mr. F. P. Dewey, in the Sheffield Laboratory, G.=3·39–3·40.

	I.	II.	Mean.		Atomic Ratios
P_2O_5	40·79	40·53	40·66		·286
Fe_2O_3	12·55	12·57	12·56		·079
Al_2O_3	0·10	0·09	0·10		·001
MnO	35·83	35·66	35·74	= 25·27 Mn_2O_3	·160
O in excess	1·20	1·18	1·19	11·66 MnO	·164
CaO	0·13	0·23	0·18		·003
MgO	*tr.*	*tr.*	*tr.*		
Li_2O	5·71	5·61	5·66		·188
Na_2O	0·44	0·53	0·49		·008
H_2O	3·11	3·03	3·07		·170
	99·86	99·43	99·65		

Another specimen of the more compact dull variety analyzed by H. L. Wells, afforded the following results:—G. = 3·26–3·27.

	I.	II.	Mean.		Atomic ratio.		
P_2O_5	40·25	40·51	40·38		·284		1
Fe_2O_3	16·04	15·74	15·89		·099	·191	
MnO	32·07	31·99	32·03	= Mn_2O_3 14·71	·092		
O in excess	1·47	1·50	1·48	MnO 18·80	·265		
CaO	·74	·70	·72		·010	·339	2·88
Li_2O	4·69	4·96	4·83		·161		
K_2O	0·25	0·28	0·26		·003		
Na_2O	*tr.*	*tr.*	*tr.*				
H_2O	3·32	3·41	3·37		·187		
Residue	0·90	0·90	·90			·187	
			99·86				

This last variety approaches the composition of a normal phosphate, but as before remarked it is not to be expected that such products of alteration should be homogeneous or prove to be definite mineral species. In general the above analyses show a marked correspondence with the analogous product of the alteration of the Norwich triphilite as analyzed by Craw and Mallet. The Branchville black material is, however, richer in manganese and in lithia, and fortunately we find it enveloping unaltered lithiophilite so that there can be no question as to the character of the original mineral.

In order to avoid any misunderstanding we may repeat here a remark already made, that we have observed also a variety of other black decomposition products bearing no relation to the above. One of them contains the oxides of iron and manganese simply being derived from the alteration of the carbonate (rhodochrosite); others have been derived respectively from the decomposition of eosphorite, triploidite and reddingite. The last named has often the characteristic octahedral form of the original mineral.

We would express here our sincere thanks to the three gentlemen, Messrs. Penfield, Wells and Dewey, who have assisted us in the chemical part of this investigation.

ART. XLIV.—*Note on the Fox Hills Group of Colorado;* by J. J. STEVENSON, Professor of Geology in the University of New York.

NOT far from thirty miles below (north) Denver, St. Vrain's Creek enters the South Platte River from the west. The Thompson enters from the same side several miles above Evans, or about forty-five miles below Denver; and the Cache La Poudre, in like manner, enters somewhat more than fifty miles from Denver. The towns of Evans and Greeley lie close together, the former being on the South Platte River almost fifty miles from Denver.

In 1873, I visited this region and made some observations, which were published shortly afterward. As the conclusions, which I then reached, were called in question, I took occasion before entering the field in 1878 to revisit the locality.

A line of bluffs begins on the west side of the South Platte River at a little way below the mouth of St. Vrain's Creek, and continues until within a mile or two of Thompson Creek. This bluff is more or less distinct on the north side of the St. Vrain for nearly four miles from its mouth. Similar bluffs are conspicuous along the northerly bank of Thompson for several miles, and can be traced thence to near the Cache La Poudre without any difficulty.

A low bluff-like ridge, lying at from one to three miles from the river, begins at Platteville on the east side of the stream, and is easily followed to a considerable distance northeastward from the town of Evans.

In the bluffs lying on the west side of the Platte, the rocks dip gently northward. On the opposite side the dip is insignificant; a very gentle anticlinal was observed at Platteville, and the rocks are almost horizontal or possibly dipping slightly toward the north at four miles southeast from Evans.

On the West side of the South Platte River.—Following the grade of the Colorado Central Railroad on the west side of the river, one finds, somewhat more than four miles above Evans, an outcrop of bright yellow, very friable sandstone, forming a broad band on the bluff. Fragmentary outcroppings of the same rock were observed farther down the river, but here for the first time the exposure is satisfactory.

On the Thompson, the exposure ends with the curving bluff at probably five miles from the river, and the dip along the stream is insignificant.

As already stated, the bluff begins again on the south side of the Thompson probably two miles from that stream, and is continuous thence to within a short distance of the St. Vrain.

Here again is a fine exposure of the sandstone which shows a gentle east-northeast dip. The section up to the St. Vrain is as follows, the thicknesses being estimated:

1.	Yellow sandstone	450 feet.
2.	Blue sandstone	200 "
3.	Concealed	200 "
4.	Yellow sandstone	100 "
5.	Gray to blue sandstone	50 "
	Total	1,000 "

No. 1, the sandstone already referred to as occurring in the bluffs both north and south from the Thompson, is bright yellow and for the most part extremely friable, weathering easily and breaking down into loose sand. But, at irregular intervals, vertically, it shows thin layers of darker sandstone, some of which are quite compact, while others are flaggy, though they all resist the action of the weather. The unequal resistance to the weather is so marked that south from the Thompson the bluffs are known as the Monument Bluffs. The features are exactly the same as those shown in Monument Park, north from Colorado Springs, and the peculiar forms exhibited in photographs, taken by Mr. Jackson in that Park, are accurately reproduced here. So closely do the rocks on the Platte and St. Vrain resemble those in Monument Park, that one might well be tempted to imagine that they are parts of one series, and that the series is continuous along the whole face of the mountain.

This locality was visited by me in 1873,* in company with Mr. J. A. P. Kelley of Evans. and in 1878 with Dr. J. Innes and Mr. S. A. Stevenson of Evans, and Mr. A. J. McClure of Bellefonte, Penn. For the greater portion, the soft, yellow sandstones are devoid of fossils, but here and there *Halymenites major* Lesqx. occurs, and occasionally one stumbles on a little nest of *Ostrea*. The harder layers are quite different, many of the more compact being crowded with the *Halymenites*, while most of the flaggy layers contain Fox Hills fossils, among which are *Ammonites lobatus*, *Nucula cancellata*, *Mactra Warrenana*, and numerous other species. Other layers are crowded with fragments of carbonized wood, and frequently one finds in such layers oblong cavities, six inches long, filled with carbonaceous matter in oolite grains and closely resembling the roe of a large fish. In 1873, Mr. Kelley discovered a thin layer containing impressions of dicotyledonous leaves. But the leaf specimens, with nearly all the other specimens obtained during that visit,

* Notes on the observations made in 1873 were published in the Proc. Lyc. Nat. Hist. of N. Y. for Jan., 1874; in the Proc. Amer. Phil. Soc. for 1875; and in the report to Lt. Wheeler, published in 1876.

were destroyed by an accident to the building where they were stored in Evans. During my last visit the leaf bed could not be found.

These fossils can be procured between the Thompson and St. Vrain from a high knob near the Stone House, but localities are numerous both north and south from the Thompson, specimens having been obtained by me from both sides of that stream, and from the north side by persons connected with the Geological Survey of the Territories.

The blue sandstone appears first above the Stone House, and physically differs little from the overlying yellow sandstone. It contains, however, no inconsiderable proportion of shale, while shaly layers are few in the other rock.

The interval, No. 3, as given in the section is too small, but no direct means of determining the thickness was at my disposal, and the calculation was made roughly by depending on the rate of dip at the southern termination of the bluffs at St. Vrain. The sandstones at the base of the section are exposed on the St. Vrain at nearly three miles from the river. They resemble the higher sandstones in structure, and as far as examined proved to be non-fossiliferous.

The relation of this enormous mass of sandstone to the coal beds mined by the St. Vrain Company could not be made out directly, as there is no way of connecting the exposures; but a barometric line carried over to the mines seems to indicate that the coal at those works lies not far from the horizon of the concealed interval. There is no evidence that any faults exist in this vicinity. Coaly material was obtained in borings, begun on the north side of St. Vrian in the sandstone at the base of the section.

On the East side of the South Platte River.—In 1874, Dr. J. Innes made several borings in search of coal at about five miles southeast from Evans. No. 1 was begun in dull, yellow sandstone, moderately coarse, containing small ferruginous nodules with *Halymenites major* and shells; but only fragments of the latter were seen, sufficient, however, to show that they belong to characteristic species of the Fox Hills group. This boring was carried 268 feet and gave the following section:

1. Sandstone	52	feet.
2. Carbonaceous shale	4	"
3. Yellow sandstone	10	"
4. Light shale	50	"
5. White sandstone	40	"
6. Blue shale	10	"
7. Blue sandstone	10	"
8. Alternations of sandstone and shale	92	"
Total	268	"

Certainly very different from anything exposed on the western side of the river. The rocks here are almost horizontal, but there seems to be a very slight dip toward the north. Accompanied by Dr. Innes, and Messrs. Miller and Stevenson of Evans, I followed up the gulch from this boring to No. 2, which is but a short distance from the last and only a few feet higher. Between the two is a blossom of *coal* or carbonaceous shale. Almost immediately north from the gulch and at barely 100 feet above No. 1, a third boring was put down, in which the following section was obtained:

1.	Dirt	10 feet.
2.	Sandstone	10 "
3.	Fire clay	2 "
4.	Sandstone	14 "
5.	*Black shale*	16 "
6.	Sandstone	21 "
7.	Fire clay	1 foot.
8.	*Coal* with a little shale	2 feet 10 inches.
9.	Interval	28 " 3 "
10.	*Coal*	0 " 2 "
	Total	105 " 3 "

The black shale, No. 5, is very carbonaceous throughout, and No. 10 is in close proximity to the dark shale or *coal* seen between borings No. 1 and No. 2, which rests almost directly on the sandstone at the top of the section in No. 1.

At fourteen feet above the curb of this boring, a shaft was begun in order to reach the *coal bed*, No. 8 of the section; but after it had been sunk to a depth of twenty-eight feet, Dr. Innes made a boring to determine the character of the coal once more. In this, the upper portion of the shale, No. 5 was found to be a *coal bed* two feet seven inches thick; the *coal bed*, No. 8, was unchanged in thickness, while the little bed at the bottom of the third boring had swelled to six inches. But of the three beds only the middle one showed good coal, that from the others being very soft and of not merchantable quality.

The shaft shows 10 feet of debris resting on eighteen feet of sandstone. The latter contains several fine-grained, somewhat ferruginous layers, which are crowded with remains of Fox Hills species, of which many weathered specimens still lie round the dump. The best specimens obtained were carried away as the work advanced, but a box of them was selected by Dr. Innes, and sent to me in 1874 by Mr. J. A. P. Kelley of Evans. This contained the following species: *Ammonites lobatus*, *Cardium speciosum*, *Nucula cancellata*, *Mactra alta*, *Mactra Warrenana*, *Lunatia Moreauensis* and undetermined species of *Anchura*. Fragments of these were seen on the dump, and some good specimens of the univalves were obtained.

At a little distance from this shaft another boring was made, which shows eleven beds of coal in the same interval, which vary in thickness from two to thirty-one inches.

One cannot join the exposures on the east, with those on the west side of the river, as the terraced plains of the Platte are very broad from Platteville to far below Evans. At the same time, the fucoids and the mollusks are fully characteristic of the Fox Hills group, and show that the rocks on both sides of the river are of the same age. Those on the east side have been regarded as without doubt belonging to the Laramie, not to the Fox Hills Group.

The bluffs on the west side between the Thompson and the St. Vrain have been colored as *Laramie* on Dr. Hayden's map. These bluffs show Fox Hills fossils to the top; they contain no coal; no leaf-impressions were found by Dr. Hayden's corps. It is difficult to understand, therefore, why the richly fossiliferous sandstones of the bluffs should be colored as Laramie, while the underlying sandstones, without characteristic features, should be colored as Fox Hills. The bluffs along the Platte, both north and south from the Thompson and those on both sides of the Thompson, are *Fox Hills* and *Fox Hills* only. No higher rocks are exposed between Thompson and St. Vrain within five miles west from the Platte.

ART. XLV.—*Note on the Spectrum of Brorsen's Comet;* by Professor C. A. YOUNG, of Princeton, N. J.

AFTER several unsuccessful attempts, I have at last, on April 1st and 2d, obtained fairly satisfactory observations of the spectrum of this comet. It consists of three bands, like the spectra of all the other comets hitherto observed, the bands being well defined at the lower (least refrangible) edge and fading out towards the upper. The spectrum is so faint that observation is very difficult, and I was able to determine the position of only one of the bands—that in the green, which is much brighter than the other two.

The instrument employed was the 9½ inch refractor of our new observatory, armed with a one-prism spectroscope of sufficient dispersive power to separate the D lines clearly; the eye-piece has a micrometer which carries a bar thick enough to be seen on the back-ground of even a very feeble spectrum. The observation was made by placing the bar so that the bright edge of the band should be just visible as a thin line, the rest of the band being occulted. The instrument has also a scale like that of the ordinary chemical spectroscope, and the position of the micrometer-bar is determined both by the reading

of the micrometer-screw and by the reading of the scale, illuminated for a moment after the bar has been set.

On April 1st I got three scale readings—respectively 99·9, 100·0 and 100·4, the value of one scale division in this part of the spectrum being very nearly 25 units of Ångström's scale, or about double the distance between the extreme lines of the *b* group, the readings decreasing with the wave length.

Just before dark b_1 in the spectrum of daylight coincided with 100 on the scale; also, immediately after the third pointing and without disturbing the telescope, spectroscope, or micrometer, the flame of a Bunsen burner was presented to the slit, and the lower edge of the green band in the well-known spectrum of this flame was found to show itself at the edge of the occulting bar precisely where the comet spectrum had been. We may therefore fairly conclude that the lower edge of the central band in the comet spectrum had a wave length of very nearly 517 millionths of a millimeter. The observation of April 3d confirms this, though but a single reading could be obtained. The only special interest in this observation lies in the fact that in 1868 Mr. Huggins obtained a somewhat different result for this same comet.

In an elaborate paper published some years ago by Vogel in Poggendorff's Annalen upon the spectra of comets, he comes to the conclusion that there are several different kinds of cometary spectra, the differences lying merely in the wave-length of the bands. But he seems to have reached this conclusion by assigning rather too high a degree of accuracy to the observations. With the exception of Brorsen's comet, it would seem that the discrepancies between the different results are entirely within the range of probable error, and that there is no valid reason for supposing more than a single cometary spectrum, slightly modified in different comets by differences of pressure and temperature.

It would now appear from my observations that Brorsen's comet also must fall into line with the rest.

I am entirely at a loss how to explain Mr. Huggins's result. It can hardly be that the comet has really changed its spectrum in the meanwhile, and a careful reading of his account (Proc. of the Royal Society, vol. xvi, p. 388) gives no light as to how an error could have crept into his work; on the other hand, every precaution would seem to have been taken.

However this may be, I am quite positive as to the accuracy of my present result—that the middle band of the spectrum of this comet now coincides sensibly (to a one-prism spectroscope) with the green band in the hydrocarbon spectrum.

The comet is moving very nearly in the path assigned by the ephemeris of Schulze. It is easily visible in the 3-inch finder of the equatorial, and in the telescope itself appears as

a round nebulosity, between 30″ and 40″ in diameter, without definite nucleus, though much brighter in the center. Before the new moon a faint tail was visible, about one-half degree in length. It appeared like a thin streamer, much narrower than the head of the comet, perfectly straight, and directed from the sun.

Princeton, N. J., April 5, 1879.

ART. XLVI.—*On the Hudson River Age of the Taconic Schists, and on the Dependent Relations of the Dutchess County and Western Connecticut Limestone belts*; by JAMES D. DANA.

THE paper by the writer on the Relations of the Geology of Vermont to that of Berkshire, in volume xiv of this Journal (1877), closed (on p. 264) with the following paragraph:

"The magnitude of the results are strong evidence that the so-called limestone-area is really but a small part of a larger region of cotemporaneous disturbance and uplift. The true breadth of the area, as well as length—whether it reached to the Connecticut Valley on the east and to the Hudson River Valley on the west, and so had the breadth of the Appalachian disturbance of a later epoch, or whether it had narrower limits —may be ascertained by studying the stratification. Some of the results of such a study as regards Connecticut and a portion of New York I propose to give in another paper."

Since the above was written I have spent much time in endeavoring to complete my observations in Connecticut and the neighboring counties of New York. I have sought to determine the strike and dip and stratigraphical relations of the rocks of Western Connecticut—points on which Percival's Report contains little, since he aimed chiefly to describe the *kinds of rocks and their geographical distribution*, and did not note where, in any case, lines of stratification and of lithological distribution were, as is often true, not coördinated.* I have

* Dr. Percival was a very exact man in all his work. He made great numbers of observations on the dip of the crystalline schists of the State, but, unfortunately, did not publish them. They had a secondary importance with him because he believed that the different kinds of crystalline rocks were formed from an original crystallizing magma by successive segregations, and did not credit the ordinary views as to stratification and metamorphism. Lines of bedding very often strike across the boundaries of his lithological areas, showing that the latter as laid down on his map, while of interest, are no guide to the stratification, except in the case of the limestone areas and those of a few other formations of persistent lithological characters. It is due to Percival to say that his theory did not lead him to the slightest perversion of the stratigraphic or other facts before him, but only to a misappreciation of some of their bearings; and had the State of Connecticut been more generous to him in its allowance of time for the completion of the survey, and of money for the publication of his notes, there would have been little left for later geologists to do.

made observations toward the same end, and also widely, over Dutchess and Westchester Counties, New York. The work is still far from finished. But the discoveries by Mr. Dale at Poughkeepsie throw so much light on the general question at issue—the age of the Taconic schists, when they are connected with the facts already learned, that I here anticipate my fuller memoir by a brief statement of the facts and their bearing.

1. On the Hudson River Age of the Taconic Schists.

(1.) The discovery, by Mr. A. Wing, of Trenton fossils, *Trinucleus concentricus* and other species, in beds of the crystalline limestone formation of Vermont that directly adjoin and underlie conformably the slates of the north-and-south Taconic belt, has established the fact that these Vermont slates are of the age of the Upper Trenton or the Hudson River group; and the fact that this Taconic belt continues southward, in an uninterrupted line, into and through Western Massachusetts, constituting the Taconic Mountains (lying on the boundary between that State and New York), and the additional fact that the same great limestone formation follows the belt through its course and underlies, in a synclinal, its slates or schists—as the writer has shown, the limestone of the east side dipping under the mountains and becoming the limestone of Copake and Hillsdale on the west—affords scarcely less positive proof that these Berkshire Taconic slates also, the original typical Taconic slates of Emmons long supposed to be Cambrian or pre-Silurian, are of Hudson River age.

This conclusion loses nothing of its certainty in consequence of the fact of a change in the schists of the belt from argillaceous schists at the north (one source of the roofing-slate industry of Vermont), to hydromica, chloritic and garnetiferous mica schists, and staurolitic schists, toward the south extremity of the mountains; for the introduction of hydromica schists (formerly called *magnesian* and *talcose schists*) takes place in Vermont not far from the localities that afforded the fossils; and these hydromica schists continue the whole length of the belt, though more chloritic, more coarsely micaceous, and often garnetiferous, to the south. As to the synclinal of the Mt. Washington portion of the Taconic range in southwestern Massachusetts, Professor W. W. Mather, in a section on Plate 16 of his New York Geological Report (1843), across the mountains fifteen miles farther south, represents the limestone of Salisbury as dipping *westward* beneath the slates while those of the west dip eastward, as they do elsewhere on that side of the mountains. Further; my own recent observations in Northern Salisbury, within three miles of the Massachusetts line, confirm those which I made just north in Western Sheffield;

that the limestone along the eastern foot of the mountains (near or west of the nearest road to them) dips *westward*—the dip being found to be 45° to 60° to the west, with the strike between N. 3° E. and N. 3° W. (true).

(2.) The recent discovery, by T. Nelson Dale, Jr., of fossils of the Hudson River group in the slates or argillaceous schists of Poughkeepsie, on the Hudson River, (sustaining the early views of the New York geologists, Professor W. W. Mather and Professor James Hall,) affords another line of approach to the Taconic Mountains of Massachusetts, and presents further evidence of their Hudson River age. In the first place, the limestone belt which lies, as above remarked, at the western foot of these mountains along through Hillsdale and Copake, and which is the western side of the mountain synclinal, branches off from Copake south-southwest through middle and western Ancram, and extends along the whole course of the valley of Wappinger Creek to the Hudson River, which it reaches only four miles below Poughkeepsie, with a single interruption of less than three miles; and it is everywhere conformable to the argillaceous schists which border it on the east, including those of Poughkeepsie; and also with those on the west, except along a region of faulting near Bangall and Stissing Mountain (a range bordering the limestone area on the west between Stissingville and Pine Plains.) This continuation of the slates and limestone northeastward, from the Poughkeepsie region to the Copake, renders it highly probable that the same limestone formation which adjoins, and is conformable to, the Hudson River slates or schists of Poughkeepsie, adjoins, is conformable to, and underlies the schists of the Taconic Mountains.

The limestone of Wappinger Valley is the Barnegat limestone of Mather—so named from a locality on the Hudson, south of Poughkeepsie, where it is burnt for lime; and this geologist gives it the course here described, mentioning that it outcrops on the Hudson at the mouth of Wappinger Creek between Barnegat and New Hamburgh, and follows the river northeastward to Copake (not noting the break in it);* and he also states that it appears on the *west* side of the Hudson and stretches on to the south-southwest, passing within one mile of Newburgh, into the town of New Windsor, in which it ends, not far from the Archæan of the New Jersey Highlands, in a small body of water called Little Pond. The writer has examined the limestone at various points along the valley; and he has found the conformability to the slates, stated by Mather, to be very generally true. The limestone area is

* Geol. Rep. 4to, 1843, pages 413 and 437. In the paragraph on p. 437 here referred to, there is some confusion as to the courses of the other Dutchess County limestone areas.

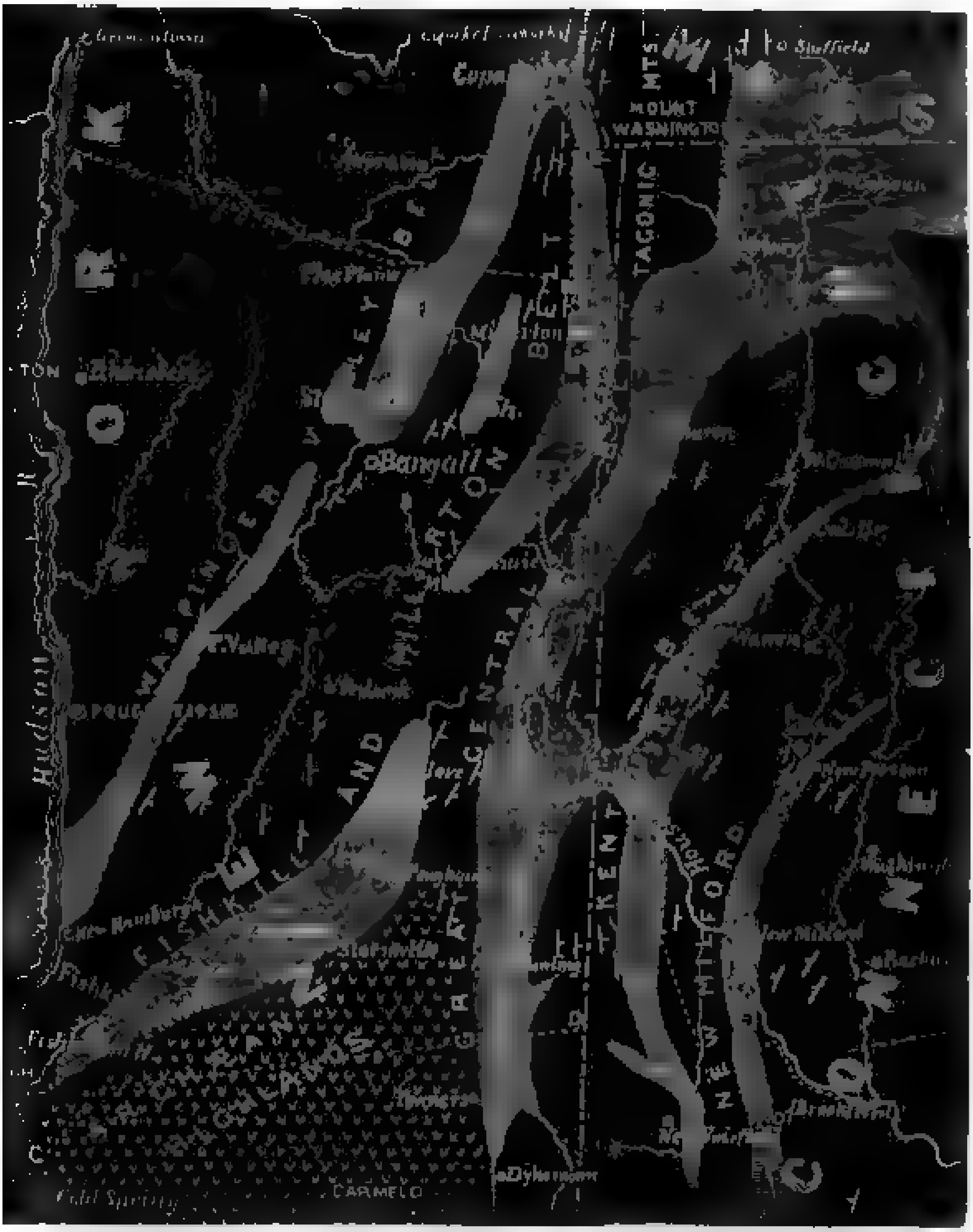
similar to the limestone region east of the Taconic Mountains in having large limonite beds, not only in Copake and farther north, but also in Central Ancram and beyond to the south; among them the Reynold's ore-pit, three to four miles southwest of the Weed ore-pit of Southern Copake, and the Morga[illegible] a mile and a half farther south. Thus the observations acco[illegible] well with the view that the limestone belt which borde[illegible] conformably the Hudson River argillaceous schist of Poug[illegible] keepsie is the same that borders the Taconic schists in Copa[illegible] and Hillsdale. If so, since the Copake and Hillsdale, [illegible] Western, belt of limestone dips under the Taconic Mountai[illegible] and comes up, on the east, as the "Great Central belt" of th[illegible] Green Mountain region, the Barnegat or Wappinger Valle[illegible] limestone is only a southwestern extension of the great lim[illegible] stone formation that outcrops around Dorset, Rutland an[illegible] Middlebury, Vermont. The occurrence of limonite beds alo[illegible] the junction between the schists and limestone, as a result [illegible] their alteration, in both the eastern and western belts, is [illegible] additional mark of general identity.

[On the accompanying map, representing a portion of Ea[illegible] ern New York, with also part of Western Connecticut and th[illegible] southwest corner of Massachusetts, the general position of tw[illegible] Dutchess County limestone belts is shown, from their outcro[illegible] along the Hudson River to their junction with one another in th[illegible] Copake limestone belt, west of the area of the Taconic Mou[illegible] tains. The map also gives the position of the southern pa[illegible] of the "Great Central" limestone belt of the Green Mou[illegible] tain region, as laid down by Percival on his geological map [illegible] Connecticut, from Sheffield in Massachusetts, and Canaan [illegible] Connecticut (where it has the width which characterizes [illegible] farther north in Berkshire and Vermont), through Salisbury an[illegible] Sharon, and thence through Eastern New York, here graduall[illegible] narrowing, to its end among contorted beds of micaceous gnei[illegible] eight miles south of Pawling, and just east and north of th[illegible] Archæan Highlands. These areas, where broadest, include som[illegible] intercalated beds of schist and isolated schist ridges. The map al[illegible] gives the position of two eastern limestone belts in Connectic[illegible] that of Kent and Cornwall, and that of Brookfield and New Milford. The T-like symbols over the map, indicate the strike and dip from my observations.]

(3.) Besides this stratigraphical evidence we now have *more positive evidence from the occurrence of Trenton fossils in the limestone of some parts of Wappinger Valley.*

Professor Mather makes the statement in his quarto New York Report (repeating it from his Annual Report of 1838), that in a bed of slaty limestone existing in the slates one-and-a-fourth to one-and-a-half miles north of Barnegat, "a few fossils were

p of Dutchess and the adjoining Counties of Eastern New York, with a portion of Western Connecticut and Southwestern Massachusetts.



utchess County is included between the boundary lines AB B.C. on the north, CD on the south. On the north is Columbia County, and on the south, Put-. The Archæan Highlands of Putnam County are a continuation of those of nge County, New York, and Sussex County, New Jersey. The light areas resent areas or belts of limestone. The notched line just west of the Connect- boundary is the course of the Harlem Railroad. *B. C.*, Boston Corners; *Br.*, Cornwall Bridge; *Mbb.*, Mabbittsville; *P. Valley*, Pleasant Valley; *Sh.*, komeko Station, on the Dutchess and Connecticut railroad—the two streams he adjoining limestone area being tributaries to Shekomeko Brook.
cale, 1-10th of an inch to a mile.

found that have been recognized as belonging to the Trenton limestone."* The names of the species are not given. The Barnegat limestone is not far distant to the south and is the next adjoining stratum. The Poughkeepsie slates dip *beneath* the limestone, the dip being southeastward. But if the rocks are in folds and the limestone makes an *anticlinal*, it is an inferior bed notwithstanding the position.† In the Barnegat or Wappinger Valley limestone, which is a dark gray, semi-crystalline rock, Professor Mather found no distinct fossils. He states that his assistant, Professor C. Briggs, "in making his section from Poughkeepsie to Canaan in Connecticut, discovered faint traces of shells at a quarry a little south of Pleasant Valley on the bank of Wappinger's Creek; but they were too imperfect for determination. They were situated between the slaty layers, which have a dip to the south-southeast of 35° to 40°." Mather quotes also Professor Briggs as reporting that Mr. William Thorn of this place (Pleasant Valley) had informed him that "he had often seen shells in the lime rock, although they are rare."‡

Had Professor Mather himself visited that quarry half a mile southwest of Pleasant Valley (about seven miles northeast of Poughkeepsie), he would not have left the fossiliferous character of the limestone in doubt, and inserted discrediting remarks in his Report. Besides, Logan's unfortunate idea of the Quebec group extending over the region, and some other wrong geological inferences, would never have had birth. At a visit to the locality this spring, in order to ascertain the facts in the case (in which I was accompanied by Professor Wm. B. Dwight of Vassar College, Poughkeepsie) I found fossils abundant and distinct. Among them we observed at the time of our visit, remains of two or three species of *Crinoids*, *Cyathophylloid corals*, *Leptœna sericea*, *Orthis tricenaria*, *O. testudinaria*, *Orthoceras junceum*,§ forms suggesting *Strophomena alternata* and fragments of *Trilobites*. What appeared to be the rounded pebbles of a conglomerate layer, proved to be worn specimens of a *Chœtetes* ——? with columns not over 1-250th of an inch in diameter. The snow was deep over the country (so deep that our geological excursion was made "on runners," since either "on foot" or "on wheels" would have been attended with some difficulty), and hence a full examination of the locality could not then be made. It cannot be, for the

* Page 401.

† Professor Mather calls the Barnegat limestone *Calciferous*, apparently because he had proved a limestone bed above it—that above referred to—to contain Trenton fossils; he could have had no other reason for it, for he says that he had no fossils from it.

‡ Page 410.

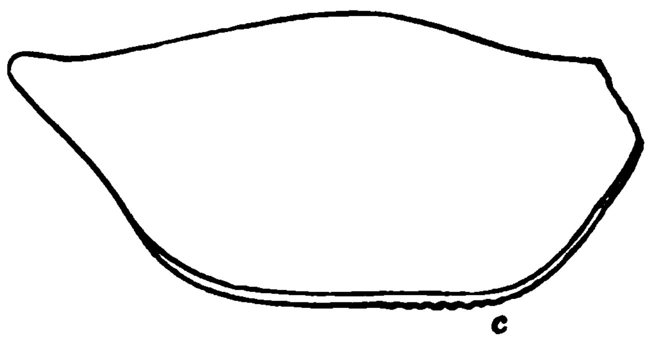
§ The form, size, and distance between the septa, are the same as in this species.

same reason, at the present time (March 21), and I have left the region to be reported on further by Professor Dwight.

Another locality of fossils in the Wappinger Valley limestone at Rochdale, four miles east of Poughkeepsie, had been visited by Professor Dwight the week before—he having been informed with regard to fossils there the day after he received my invitation to join me in the excursion—and it is not less prolific. Great surfaces are covered with the Crinoidal remains, and all the species observed at Pleasant Valley are found there; and, besides, a portion of an *Endoceras*, ten inches long and two inches wide at its larger end, and remains of large specimens of *Receptaculites*. I refer to the article following this for Professor Dwight's preliminary account of the fossils.

Previously, early in December (the day before the first snowstorm of the late snowy winter), I made a search for fossils at the northern end of the Wappinger Valley limestone, in eastern Ancram, just west of the extremity of Winchell's Mountain and not three miles distant from the Taconic Mountains, and found what I then and now believe to be the common Trenton species, *Orthis occidentalis*;* and with it there is another kind, of uncertain character, which may possibly be the Trenton *Strophomena alternata*. The specimen of the *Orthis* presents to view a section of the shell, having the size, form and thickness indicated in the accompanying figure. The thin shell is converted into white calcite (through the metamorphism) excepting in some parts an extremely thin exterior layer; and over a portion of the exterior (at *c*) there are sections of a few of the costæ. The hinge side of the shell is wanting in the specimen. A horizontal section made through the more convex (or ventral) valve was found to have the form which it should have if of the species here supposed; and so for the other valve. The evidence is therefore quite strong in favor of its being this common Trenton Brachiopod.

1.



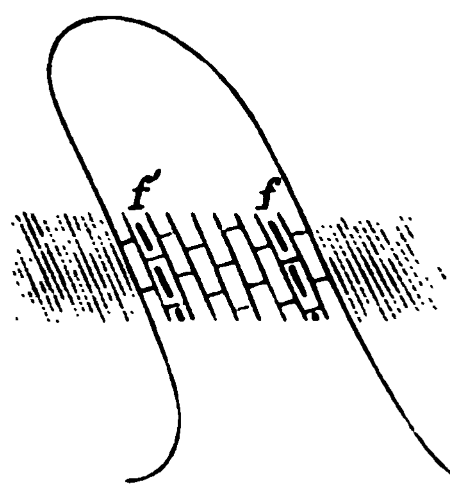
The forms referred doubtingly to *Strophomena alternata* have the arcuated outline, shape and thickness, that would belong to sections of this arcuate shell. They are of white calcite and correspond to individuals one to two inches broad and diminishing mostly from a fourth to a sixteenth of an inch in thickness. Besides the sections, there are also broad concave surfaces like the inner surface of valves. No appearance of striation can be detected in connection with any of the forms.

* The specimens were from a large freshly broken mass of limestone by the road side that was evidently derived from an outcrop near by.

I have been again over the Ancram region, but without finding other specimens—the limestone being much more crystalline than it is toward Poughkeepsie.

The fossils of Pleasant Valley and Rochdale, prove that the limestone of Wappinger Creek Valley contains a stratum of the age of the Trenton; and that of Ancram has the same bearing. The width of the part of the belt at the two former places is two-thirds to three-fourths of a mile; and since the bed containing the fossils is, at each of these localities, within 200 to 230 yards of the *eastern margin* of the limestone belt, it is probably one and the same bed. The lithological character of the rock sustains this. The *western margin* lies conformably against the Poughkeepsie "Hudson River" slate; and hence the western portion also must be Trenton. It follows then: *first*, that the belt is an anticlinal of limestone (as represented in the figure, *f*, toward the east side, being the observed fossiliferous bed); and, *secondly*, that the slate on the *east* of it is of Hudson River age, as well as that *west*. Further: these facts, and the concurring evidence from Ancram, where the limestone is essentially the Copake limestone, leave little doubt that Trenton beds continue northward to the very foot of the Taconic Mountains; and that the schists of the Taconic Mountains, like those of either side of the Wappinger Valley, including Winchell's Mountain, *are Hudson River in age.*

2.



The Wappinger Valley belt may have at centre a Chazy or other subjacent limestone stratum; and if so, the fact would only make more complete the identity of the Poughkeepsie and Vermont formations.

In the vicinity of Stissing Mountain there are quartzyte outcrops; and, if the rock is of the age of the Potsdam sandstone, the portion of the limestone next adjoining may be Calciferous. The mountain consists of fine-grained, gray gneiss, along with slate on the west, and at the southern end the gneiss contains minute zircons; I reserve the discussion of the age of the gneiss for another paper—the first draught of which was made nearly eight years since.

(4) But this Wappinger Valley limestone is not the only southward extension of the Copake limestone. Another (see Map) extends from it southward by the western foot of the Taconic Mountains through Boston Corners and Millerton; and in the vicinity of the latter place it has its limonite beds. Thence it takes a south-by-west course through Western Amenia, and

Eastern Washington. It stops in the latter town just east of Mabbitsville. But six miles south, in the next town, Unionvale, it appears again in the valley of the Clove, and follows Fishkill Creek to its junction with the Hudson. At Poughquag, it has the extraordinary breadth of three miles, and it continues to have great width past the village of Old Fishkill; but it then narrows, becomes confined to the south side of the Fishkill Creek in Glenham, and is very narrow toward the mouth of the creek.* It evidently loses in breadth in this part because of its nearing the Archæan region of the Highlands, which is not half a mile distant; and its more western course from Poughquag to the Hudson has the same origin. The Hudson River slates border it conformably on the north. Limonite beds occur along this belt in Unionvale, where is the Clove ore bed, two on Sylvan Lake, and one in East Fishkill.

Through this Millerton-and-Fishkill belt of limestone there is hence a second connection between the Hudson River slates of the borders of the Hudson River region and the schists of the Taconic Mountains.

The limestone is throughout as decidedly crystalline as in the northern half of the Wappinger Valley belt (though never coarsely so); and hence fossils would be uncommon if occurring in it at all. In many places forms suggesting a fossil origin are to be met with.

Wherever the limestone contains seams of quartz such indications rarely occur, the most suggestive appearances being small and thin isolated bits of quartz, arcuate in section. Since the silicification, or the making of the siliceous seams, was carried forward by *hot* siliceous waters (not *cold*, as in the case of silicified shells in an unaltered limestone) during a time of metamorphism in which the limestone was crystallized and quartz veins were made in the slates or schists, fossils, if any were present, would naturally have been dissolved away. Almost the only chance for recognizable forms is in places where the limestone is without quartz, and the seams and spots it contains are of white calcite. One of this kind, which I observed in the limestone seven miles north of Millerton, near the base of the Taconic Mountains, seemed to be part of a valve of a ribbed Brachiopod, and others of like suggestiveness were met with in some of the limestone cuts between Hopewell and Fishkill. Such appearances favor the expectation that distinct fossils may yet be found in this belt. Three

* I found the limestone outcropping at the village of Lithgow, and east of Mabbitsville (*Mbb.* on map), as stated by Mather. South of this, the country is high, the elevated region to the eastward (called farther south Chestnut Ridge) spreading over it, and having its rocks small in dip, with undulations, and with the limestone evidently concealed beneath. The limestone reappears where the valley opens again, along Clove Brook, and is thence continuous to the Hudson.

miles west of Hopewell I obtained specimens looking closely like the Wappinger Valley *Chætetes*, but with its structure lost.

Between the Wappinger-Valley and Fishkill-and-Millerton belts, there are other outcrops of limestone.

One area, nearly six miles long, lies between the northern ends of these belts, in the Shekomeko Valley. (See the map.) Winchell's Mountain bounds it on the east, and Husted station is toward its northern extremity. The limestone is similar to that of the Fishkill-and-Millerton belt, but has in many parts a delicate bedding that shows the action of slowly moving water during its accumulation. The accompanying figure (from a photograph) represents, natural size, figures on a specimen of blue limestone, from a ledge near Shekomeko Station (*Sh.*), which are of white calcite and similar to those alluded to above as suggestive of Brachiopods. Another specimen contains a group of *black* curving surfaces, which are unquestionably of organic origin, and look like impressions of a few successive broken segments of a *Trilobite* 1¼ in. broad.

3.

Another area exists just below the Verbank railroad station, where two small hills of a badly rifted, quartz-seamed, gnarled limestone occur, which is various in strike, but mostly nearly north and south, and is without continuation at surface either north or south. A third occurs at Arthursburg, hardly eight miles south of Verbank. I learn from Professor Dwight, that a ledge, 1,800 feet wide occurs two miles southeast of Pleasant Valley. Mather mentions one between Redhook and Milan.

Over the country between the two Dutchess County limestone belts, the dip, excluding some local exceptions, is eastward (mostly between east-by-south and east-southeast) and the beds, as has been stated, are all conformable. It is true that the *cleavage* of slates is not always conformable to the stratification; but since over this region the lamination in them corresponds in all cases with the bedding of the many intervening limestone strata, the uncertainties which are thus introduced do not affect the above general statement as to conformability and eastward dip. In a supplement to this paper, the actual dips and courses observed, will be given.

Rocks.—The schists and limestone east of the Taconic Mountains are more crystalline than those *west*, and the crystalline

racter diminishes from these mountains *westward* toward the lson, just as it diminishes along their line northward toward tral Vermont. The rocks are mica schist and hydromica st, and to the south micaceous gneiss, over the eastern part)utchess County; but, approaching Poughkeepsie, the schist ›art fails even of the glossy luster, and becomes dull argil-ous and partly carbonaceous schist. North of Dutchess nty, in Columbia County, argillaceous schist is the prevail- rock, and it is often carbonaceous in Ancram and part of ›ake. The micaceous gneiss of the Taconic schist belt is l seen two miles west of Pawling; and here, against its ern side, between it and the limestone, there lies a large)nite ore-bed. And this gneiss-like character continues to ;xtremity, south of Towner's, where, in a dry portion of a e marsh, north of Croton Lake, the limestone is exposed to v, alternating with coarse gneiss. In the slate ridge next t, the northern extremity of which is called Winchell's ıntain (west of Boston Corners and Millerton), the rock is llyte, and hydromica schist, partly chloritic; but to the th, it becomes gradually coarser, being a mica schist on its ern or more crystalline side, at Wassaic; and ten miles farther ;h, a decided mica schist on its western side, and still coarser ;he east; and even gneissoid south of this.* Mather recog-›d the same changes, in this range of slate, stating it thus p. N. Y. Geol., p. 433): "in its northern part, of slate and ›se and chloritic slates; the middle part, of mica slate; and southern portion, of gneiss." The extremity of the "Great tral" limestone belt is in the area of Croton lake.†

'he facts in Dutchess County thus show that argillaceous st, hydromica schist, mica schist of garnetiferous, chloritic, .rolitic and other varieties, and micaceous gneiss, which are occurring rocks of the so-called "Taconic system" or ıconian," are here of one and the same age, and they leave e reason to doubt that they are, together, *of the age of the lson River Group.*

;uartzyte occurs adjoining the Archæan, southwest of Mat-van, three miles from the Hudson River—a locality pointed to me by Mr. Charles M. Wolcott of Fishkill. The quartzyte

* According to a section by Prof. N. H. Winchell (received by the author from n 1872) from the top of Winchell's Mountain eastward to Lakeville, seven , along a line ¾ m. north of Millerton, the rock of Winchell's Mountain west e summit is argillyte, and east of it mica schist; next east is the Millerton tone nearly two miles wide; next, mica schist, of the same width, having, e west a thin stratum of "compact, fibrous hornblende schist, somewhat mica-ı" (as seen in a section on the Connecticut Western R. R.); and then, the tone of Lakeville. The dip is stated to be north of east, except at Lakeville e there is a low anticlinal.

† It is rather probable that an outcrop exists two miles farther south, in the f another pond south of Dykeman's, though none is in view. There is here l termination of the valley by high Archæan hills.

was jointed and obscure in its bedding; but since a limonite deposit (usually situated in these regions, between conformable strata of schist or quartzyte and limestone) adjoins it, and the proprietor, Mr. Wolcott, found this one resting on beds approaching the quartzyte in character, it is very probable that the stratum is conformable with the limestone, whose outcrops are not far distant, and that it is of the age of the Potsdam sandstone. The adjoining portion of the limestone may hence prove to be Calciferous or Chazy. Quartzyte rests on the Archæan also at Poughquag, but in nearly horizontal beds (see this Journal, III, iii, 250, 1872) indicating a fault between it and the adjoining limestone. Mather mentions its occurrence also at Shenandoah.

At Glenham near Fishkill, a flesh-red, coarse granite-like stratum (or "bastard granite," as it has been called) lies between the limestone and the slate, conformable to both; and it is evidently one of the stratified deposits, as is shown by its conformable position, and its taking the color of the slate near the junction. The adjacent Archæan Highlands were the source of the coarse granitic sand of which it was made.

2. DEPENDENT RELATIONS OF THE TWO DUTCHESS COUNTY LIMESTONE BELTS AND TWO EASTERN BELTS IN CONNECTICUT.

The preceding map also represents, from Percival, two eastern belts of limestone in Connecticut, the *Kent* belt and the *New Milford* belt; and I may add that I have been over these regions pretty thoroughly, and can attest to Percival's correctness.

Viewing these belts and the three to the west together, and remembering that the Great Central belt is identified with the Green Mountains through Massachusetts and far into Vermont, it seems to be a safe conclusion that all are parts of one system; and that they owe their existence to a series of extensive cotemporaneously-made folds of the wide-spread Lower Silurian formation of the region. The New Milford and Kent belts are the *opposite sides of a synclinal;* for the schistose rocks between have, as I have found, a westward dip along the eastern portion, and an eastward dip along the western portion, as indicated by the symbols for the dip and strike on the map. The Great Central belt and the Kent belt *pass one into the other* in the vicinity of South Dover (see map), and also to the north in the eastern part of Canaan, and thus they are one.

Over the large gneiss area next west of Kent, the schistose rocks are, for the most part, conformable to the adjoining limestone belts—the strike about N. 20° E. along the southern half and on the eastern side of the northern half, and with N. 50° E. as the average near the Housatonic River, as if from a

ench in the mass. On the southern portion of the *east* side h north and south of Kent, and also along a large part of *west* side, the rock adjoining the limestone is *quartzyte;* l next follows gneiss; *the quartzyte in several places is gneis-l, and graduates into the hard gneiss.* South of Sharon, the k next to the quartzyte is *granulyte*, and there is a partial nsition from one to the other. The quartzyte of the two es of the area is, with little doubt, the same stratum, and bably the Potsdam sandstone; and in that case the con-mable gneiss will correspond to inferior beds of the Primor-l, and the adjoining portion of the limestone belts may be ciferous; further, the strata make an anticlinal over the ervening area of gneiss. This area includes some uncon-mable ledges, both in the northern and southern half, in ich occur chondroditic limestone, syenyte, beds of titan-ous magnetite, and hard gneisses, which may be Archæan; l if so, they are outliers of the large Archæan area of the ghlands which exists to the southwest.

INFLUENCE OF THE LIMESTONE BELTS ON THE FEATURES OF THE SURFACE.

Limestone being a brittle rock, the region of flexures, whatever thickness of the overlying mass, would have been profoundly tured, especially in anticlinals; and being also a soft rock, it uld have been easily carried away by denuding agencies. e limestone belts are the chief courses, as Percival pointed , of all the greater valleys and streams of the limestone ion; and in these valleys, as I have found, the underdip-g side of the limestone is generally the bold, precipitous e, owing to the undermining which it has occasioned. This o generally true that vertical fronts in these metamorphic ions (and I may add in Westchester County as well as ther north and northeast) are pretty sure evidence of out-pping limestone below.

4. CONCLUSIONS.

1. The Taconic schists are, according to the evidence, of the of the Hudson River group.

2. The conformability in the rocks between the eastern of the necticut belts and the Hudson, being established by obser-ion, the five limestone belts are plainly, as above suggested, five outcropping bands of the Lower Silurian limestone for-tions, brought to the surface by a series of flexures.

3. The disturbance which upturned and crystallized the lime-nes and other conformable formations in the Green Mountain a, through Vermont and Massachusetts, extended south over

certainly a large part of Western Connecticut, and over Eastern New York at least to the Hudson.

That hard gneisses and mica schists are among the included formations does not, in any way, affect the evidence or the conclusions here deduced.

These conclusions coincide partly with those reached by Professor Mather, as stated on pages 438, 464, and 628 of his Report, namely: (1) That the limestone of Eastern New York and the Green Mountain region, including that of Westchester County down to New York Island, is of the Trenton or Calciferous (Canadian) periods; (2) that the slates, gneiss, mica schist and other rocks, directly associated with the limestone in Massachusetts and elsewhere, are of the Hudson River age; (3) that the quartzyte is of the age of the Potsdam; (4) that the making of the Green Mountains and the metamorphism of Western New England, took place at the close of the Lower Silurian. Proposition (1) appears to me to be established, if we admit, in addition, that the limestone may in some places be in part Primordial, and leave out of consideration, for the present, that of Westchester County. Proposition (2) is pretty well demonstrated as far as the slates or schists of the Taconic Range are concerned; but,—as I present in the second of my articles on Berkshire geology—we cannot say now of the gneiss and mica schist ridges to the east of the Taconic range more than this, that they are Lower Silurian; and among the gneisses are those also of local Archæan areas. Proposition (3) is almost certainly true for part of the quartzyte, but it is not yet safe to say this of all. Proposition (4) has strong support in all the observations which I have made in the Green Mountain region.

Professor Mather has a separate chapter on "Primary rocks" under which head he includes the rocks of the Highlands, and, with these, the gneisses and mica schists of Westchester County and New York Island. The distribution of the limestone areas of Westchester County with reference to one another and those of Connecticut, and their stratigraphical relations to the gneisses and mica schists associated with them, are a basis of evidence on this question of age, and the facts I have observed and mapped I shall present in a following number of this Journal.

The nature and stratification of the schistose rocks intervening between the Connecticut limestone belts I have studied with some detail, and I propose, after further investigations, and the removal of some doubts as to the limits of the included Archæan, to make these also the subject of another paper.

'. XLVII.—*On some recent Explorations in the Wappinger 'alley Limestone of Dutchess County, New York;* by Professor 'M. B. DWIGHT, of Vassar College, Poughkeepsie, N. Y.

.Y attention was called to the possible fossiliferous character ıe Wappinger Valley limestone by an invitation from Pro- ›r Dana to join him in examinations at Pleasant Valley, of a ·rted locality of fossils doubtingly mentioned by Professor her.* In order to further the object in view, I made ıiries with regard to another reputed locality, at Rochdale, the next day I was gratified to find the limestone there ınding in fossils. Since the excursion to this place and .sant Valley with Professor Dana, which took place a days later, I have continued my search in the Barnegat Vappinger Creek limestone, he leaving the field to me, and discovered still other localities; and it is the object of this ɜr to mention the facts thus far ascertained.

.s my acquaintance with this part of the country has been a brief one, and as my researches have been conducted in scanty hours that could be snatched from my collegiate k during the last four weeks, the results which I here put ·ecord should be regarded as merely preliminary to the e careful investigations of this interesting formation which pe to make.

he first locality which I examined was one at Rochdale, 're alluded to, where objects of peculiar forms had been rted to have been found, though there is no evidence of scientific examination. It is situated four miles northeast 'oughkeepsie, on the premises of Mr. Henry Titus.† The stone here has a dip of 60° southeasterly, with a strike of ·6° E. (true). The examination, though short, afforded me ıdant evidence of fossils, and some determinable species, as ·ws:—*Leptæna sericea*, an internal cast of the ventral valve, ving the characteristic form of the callosities for visceral ɜhment, and the striæ in reverse; two specimens of *Orthis ıaria;* small encrinal columns in countless numbers; a spiral l, two and a half centimeters in diameter, exhibited only in on, imbedded in the rock.

ɜsides these, there are many specimens of a species of *Recep- 'ites.* Groups of cylindrical or club-shaped columns, half nch or so long, project inward, somewhat radially, from a ›w but rather firm shell of irregular form which varies much

. Y. Geol. Report, 1843.

† take this occasion to acknowledge my indebtedness to Professor T. J. ıs, of Vassar College, for information of this locality, and assistance in point- ıt fossils, and to Messrs. Henry and Richard Titus, proprietors of the Roch- woolen mills, for courteous coöperation in the work.

in size; they consist of the limestone and are evidently the fillings of the tubes of Receptaculites. They are so imbedded in the rock that I have not yet been able to detach any for special study, as I propose soon to do.

My second trip to this locality, a week later, was made in company with Professor Dana. I found, at this time, another distinct specimen of *Leptæna sericea*, one *Escharopora recta*, one *Ptilodictya acuta*, a pygidium of a trilobite, several specimens of *Orthis tricenaria*, an *Orthis pectinella*, one *Endoceras* twenty or twenty-five centimeters long, one small *Orthoceras*, two of *Orthis testudinaria*, and some *Chætetes* of minute columnar structure.

On the same occasion we visited a quarry on Wappinger Creek, about half a mile below Pleasant Valley, where Mather reported faint traces of shells to have been found, "too imperfect for identification." We found abundant evidence of the fossiliferous character of the rock, the fossils being generally similar to those at Rochdale. In a subsequent examination of my specimens here collected, I obtained one well-defined specimen, and several small fragments, of *Strophomena alternata*,—showing its characteristic arrangement of striæ; also, very abundantly, the Chætetes found at Rochdale, from two inches to one-quarter or less in diameter. The large specimens are sometimes semi-globular, and suggest *Chætetes lycoperdon*, but for the microscopic tenuity of the columns; but other specimens are pyriform, and I am not certain as to the normal shape. The diameter of the columns is less than 1-200th of an inch. As it appears to be new, I propose for it the name *Ch. tenuissima*.

My subsequent trips have been taken alone. On the farm of Mr. Brittenberger, two miles southeast of Pleasant Valley, east of Wappinger Creek, I found a second and parallel outcrop of limestone, 1800 feet wide, separated by slate from the main body of the Wappinger Valley belt. The rock is here filled with limestone pebbles of various sizes and lighter in color than the mass. Many of these may have been organic, and very likely corals, but crystallization has so obliterated the structure that if detected at all, it must be by microscopic examination. There was one specimen which is probably an encrinal column about seven centimeters long, and seven millimeters wide.

I have made examinations at Salt Point, on Wappinger Creek, at the junction of Salt Point Creek, ten and a half miles northeast from Poughkeepsie, and also at a number of places between Salt Point and Pleasant Valley. At Salt Point the limestone has a width of 2200 feet, and it is about that width, or somewhat wider, toward Pleasant Valley. It is mostly on the west side of the creek, and for a distance of four miles south of Salt Point, it varies from the greater part of the outcrop by

having a westerly dip of 70° to 85°, the strike averaging about N. 26 E. (true). Thus far I have succeeded in finding here only the spiral shell met with at Rochdale, and three small but very distinct Orthocerata. This spiral shell occurs in particular layers extending through this entire section; some specimens appear to be scattered through the rock, but in these layers they exist in immense numbers. On a single surface of 50 square centimeters, which I broke out of the solid rock, there are more than twenty distinct specimens. This is beyond the average, but the specimens are often so numerous as to crowd upon each other.

The best localities I have discovered are in two quarries of F. B. Wallace, on Wappinger's Creek, respectively one and one-quarter and one and one-half miles below Salt Point; and in two cuts on the Poughkeepsie, Hartford and Boston Railroad track, two miles north of Pleasant Valley. Generally only the simple spiral line is preserved in section. In many cases, however, more or less of the tube of the whorls remains, quite hollow, but its surface too granular to allow the preservation of any marking. The spire in many cases shows a depression of about two millimeters below the surface of the outer whorl. In most cases no septa are visible, but among some fine specimens, from the lower Wallace quarry, several show distinct internal, transverse septa. One, which is unusually good and sharply defined, shows as many as fifteen septa in its four whorls in good state of preservation. I have not yet been able to make out clearly a siphuncle. Most of the specimens exhibit four whorls, and some traces of a fifth; the rate of expansion in the width increases gradually, the spirals being closely coiled. A few of these spiral shells are loosely coiled; and some, whose whorls present an angular edge, are of essentially different character from the others. From present appearances I should judge most of these shells to be those of *Trocholites*, but I hope soon to secure more decisive specimens.

At Manchester, three miles east of Poughkeepsie, no organic remains appeared, except a beautiful fucoid, which had much resemblance to *Buthotrephis gracilis*, and covered a large slab of rock.

In a visit to an outcrop on the Hudson River, one and one-half to two miles south of Milton Ferry, I discovered no fossils except a good specimen of *Leptæna sericea*, in the rock quarried from the limestone near where it borders on the shale that lies on its north side.

The results in fossils, of my examinations, the specimens of which were taken in every instance from the solid rock in place, may be summed up as follows:—

From Rochdale.

* *Orthis tricenaria;* several.
* *O. pectinella;* one.
* *Leptæna sericea;* two.
* *Escharopora recta;* one.
* *Ptilodictya acuta;* one.
Caudal shield of small trilobite, probably *Asaphus vetustus;* one.
Endoceras (probably *proteiforme*); one.
Orthoceras not well defined; one.
Spiral univalves; several.
Chætetes, named above *Ch. tenuissima;* many.
Encrinal columns; exceedingly numerous.
Receptaculites; numerous.

From Pleasant Valley.

* *Orthis tricenaria;* several.
* *O. pectinella;* one.
* *O. testudinaria;* two.
* *Leptæna sericea;* one.
* *Strophomena alternata;* one or more.
Chætetes tenuissima; very common.
Encrinal columns; abundant.
Bellerophon?; one.
Undetermined corals; several.

Between Salt Point and Pleasant Valley.

Trocholites?; exceedingly numerous.

Oncoceras constrictum?; one specimen, two centimeters in length and same in width.

Orthocerata; one, three centimeters long, with twelve septa; one, about a centimeter long, with five septa.

Manchester.

Fucoids (*Buthotrephis gracilis?*); one.

Besides other conclusions from these researches, the following may be safely drawn:—

1. The "Barnegat limestone," contrary to views hitherto presented, is a highly fossiliferous formation, though on account of alteration, fossiliferous localities are rare compared with the exposure of rock.

2. The fossils are apparently those of the Trenton limestone, and therefore immediately underlie the adjoining shales which are now referred to the Hudson River group.

3. In the presence of the Chætetes of delicate structure, and of the layers thickly packed with spiral shells, the limestone appears to differ from that of any other known region of this formation.

Vassar College, Poughkeepsie, N. Y., April 7, 1879.

* Clearly defined as to specific character.

ART. XLVIII.—*Observations on the Planet discovered March 21st;* by C. H. F. PETERS. (From a letter to the editors dated Litchfield Observatory of Hamilton College, Clinton, N. Y., April 2d, 1879.)

I TAKE pleasure in communicating the following observations on a planet discovered on March 21st, the only ones the bad weather has permitted me to make.

1879.	H. C. mean t.	α (194)	δ (194)	No. of comp.
March 21	$14^h 15^m 47^s$	$12^h 12^m\ 3^s{\cdot}91$	$+\ 9^\circ 26' 30''{\cdot}2$	20
" 31	9 23 12	12 4 20·07	+11 1 3·9	12
April 1	9 11 13	12 3 34·63	+11 10 1·6	10

The planet is bright eleventh magnitude. On the same evening I found still another planet, 10th magnitude, and observed it;

March 21.
$11^h\ 32^m\ 21^s$ m. t. $\alpha = 11^h\ 58^m\ 45^s{\cdot}49$; $\delta = +9^\circ\ 18'\ 2''{\cdot}8$ (16 comp.)

As my computations from the elements (the Berlin ephemerides have not yet arrived) did not indicate any of the older planets in that place, I had reason to believe this one too a new one, and accordingly gave public notice of it. Professor Foerster, however, remarks that this is *Leto* (68). And indeed, I find now, that in the elements of *Leto* given in the Berlin Jahrbuch there is an error of print made in 1877, and perpetuated through the later volumes until 1880. The epoch printed there, 1874, should read instead 1864.

ART. XLIX.—*Note on the Stratigraphy of the Huronian Series of Northern Wisconsin; and on the Equivalency of the Huronian of the Marquette and Penokee Districts;* by R. D. IRVING.

IN the number of this Journal for September, 1876, Major T. B. Brooks has given, in a scheme of equivalency for the strata of the different Huronian districts in the neighborhood of Lake Superior, a synopsis of the Huronian section on Bad River, Northern Wisconsin, which is quite erroneous. The error has arisen chiefly from the failure to recognize the existence of a very important break in the strata—which break has indeed given the river an opportunity to cut its way through the Penokee range—and also from the difficulty in marking the line between the two great and totally distinct series, the Huronian, and Keweenawan or Copper-bearing series. Major Brooks's section is professedly a rough one only.

I have myself recently completed a study of my field results over the Huronian belt of this part of Wisconsin, as also of over one hundred thin sections of the rock specimens gathered, and have made a section which I think may be regarded as final. A synopsis of this is given below, as it will appear in vol. iv of the Wisconsin reports. I should say here that in beginning my lithological work on the Huronian of this region, I was aided by a detailed microscopic description of nine selected specimens furnished by Mr. A. A. Julien. In the year that has elapsed since then I have familiarized myself with this (to me) new, and all-important method of investigation, and have examined sections from nearly every ledge of importance within the Huronian area.

Synopsis of the Stratigraphy of the Huronian of the Penokee Region, Wisconsin.

LAURENTIAN.

Chloritic hornblende-gneiss and pink quartzose granite.

HURONIAN.

(Non-conformable with the Laurentian.)

Formation.		Average thickness.
I. Tremolitic (Julien) crystalline *limestone*		90 ft.
II. (A) Arenaceous white *quartzite*, often brecciated	35 ft.	
(B) Magnetitic quartz-schist..	5 ft.	40 ft.
III. *Siliceous slaty schists*; including quartzite, "argillitic" mica schist, and novaculite; all having much quartz, and none ever showing any amorphous material		410 ft.
IV. *Magnetic belt*; including (*a*) banded magnetic quartzite—gray to red quartzite, free from, or lean in iron oxides, banded with seams, from a fraction of an inch to several inches in width, of pure black granular magnetite only rarely mingled with the specular oxide; (*b*) magnetitic quartzite—the magnetite in very varying proportions, pretty well scattered throughout, and mingled with the specular oxide in proportions varying from nothing to a predominating quantity; (*c*) magnetitic quartz slate, the magnetite pervading the whole, and mingled with the specular oxide, as before; (*d*) slate like (*c*) but largely charged with tremolite or actinolite; (*e*) arenaceous to compact and flaky quartzite, free or nearly so from iron oxides; (*f*) thin-laminated, soft black magnetitic slate; (*g*) hematitic quartzite, the iron oxide the red variety; (*h*) garnetiferous actinolite schist, or eclogite; (*i*) diorite, which is restricted to the western end of the Huronian belt. Kinds (*a*) to (*d*) all carry much pyrolusite, or other manganese oxide. These varieties have no persistent stratigraphical arrangement, and are named here in order of relative abundance. Total thickness about		780 ft.

Formation.	Average thickness.
V. *Black feldspathic slate;* consisting of orthoclase grains imbedded in a paste of biotite, pyrite, limonite (Julien) and carbon	180 ft.
VI. Unknown, always drift-covered	880 ft.
VII. Dark gray to black, aphanitic *mica-slate*, having a wholly crystalline base of quartz and orthoclase, with disseminated biotite scales	120 ft.
VIII. Unknown, but probably in large part the same as VII	290 ft.
IX. Chloritic, pyritiferous, massive *diorite* (Julien)	150 ft.
X. Black, aphanitic *mica-slate*, like VII	25 ft.
XI. Covered, but probably black mica-slate	280 ft.
XII. *Black mica-slate;* aphanitic; at times chiastolitic (Julien)	225 ft.
XIII. Chloritic *diorite-schist*	35 ft.
XIV. *Black mica-slate*, like XII, often chiastolitic	375 ft.
XV to XVIII. Alternations of black *mica-slates*, with *quartzites* and quartz-schists	675 ft.
XIX. *Greenstone-schist;* aphanitic; the hornblende and plagioclase much altered	260 ft.
XX. Covered; but probably like XXI	525 ft.
XXI. *Mica schist;* from aphanitic to medium-grained; including bands of light-gray quartz-schist, the mica becoming subordinate; all varieties having a background of quartz; the mica wholly biotite; penetrated by veins and masses of very coarse, pink to brick-red biotite granite; total seen on Bad River	4,960 ft.
Total thickness of the Huronian in the Bad River section	10,300 ft.
Add higher layers seen farther east; same as XXII	2,500 ft.
Total	12,800 ft.

KEWEENAWAN.

(Non-conformable with the Huronian.)

Very coarse to fine-grained gabbro, including granite veins and masses.

The Bad River section does not show the entire thickness of the Huronian, for the reason that the overlying gabbros of the Keweenawan Series cut diagonally across the Huronian. Seven miles west of Bad River the whole thickness of strata between the Laurentian gneiss, and Keweenawan gabbro, does not exceed 2,500 feet, while at the same distance eastward it is over 12,000 feet.

Equivalency of the Huronian systems of the Marquette and Penokee Districts.—There can be little doubt that the Huronian basin of Marquette was once directly continuous with that in

which the Penokee rocks were deposited; there are, indeed, no facts yet on record going to show that the two rock-systems are not at the present time directly connected, though at surface the connection is obscured by the overlying horizontal Potsdam sandstone. Pumpelly and Brooks* have carried the Penokee belt uninterruptedly eastward as far as Lake Gogebic, where a deep depression, made by ancient erosion, occupied now by the horizontal sandstone, terminates the range abruptly. From here to the westernmost known portion of the Marquette Huronian is a distance of less than forty miles.

In the Marquette region Major Brooks has made out with great care and skill a succession of beds which he numbers from V to XIX. That essentially the same succession exists in the Penokee region, there can be little doubt. An attempt to make out a scheme of equivalency for basins always disconnected, based on lithology alone, would, beyond doubt, be but time wasted. In the present case, however, the two districts are really continuous, and many of the layers in the two regions so very constant in their characters, that there can be no valid objection to the attempt. It is undoubtedly true that it is very easy to make many mistakes in such a scheme, owing to the dying out of certain layers, and the variations along the line of strike of some member of the series, which, if not originally present, may have been produced by the partial process of metamorphism to which the whole Huronian system has been subjected. No scheme of equivalency can then be regarded as of any value, that is not based upon those few grand features of the stratigraphy, which are shown to be quite constant. The prominent facts in this connection, that have pressed themselves upon me while studying over my field-results in connection with the reports and typical collection of the Michigan survey, are here given. Major Brooks, whose wide experience in the several Huronian regions of the northwest, and whose skill in Huronian stratigraphy, are well known is, I believe, preparing a complete presentation of the whole subject of the equivalency of the strata of the various districts. The following are offered as suggestions toward the fuller treatment of the subject.

In Wisconsin we find at the base of the series a great bed (III) of light-colored quartzose slates and schists, over 400 feet in thickness, with characters so pronounced that it has been traced uninterruptedly for over fifty miles. The rocks of this layer vary from schistose vitreous quartzites, to argillitic mica-schists, while subordinate to it are the two lower members, the white arenaceous quartzite (II) and tremolitic crystalline limestone (III). Now in the Marquette region the base of the series is a

*Geological Survey of Michigan, vol. i, p. 183 of Report on Iron Rocks, and p. 1, of Report on Copper Rocks.

great bed of quartzite (V), including argillitic schists, and limestones, both quite indistinguishable in hand specimens from the Wisconsin rocks. From the descriptions in the Michigan reports this layer is evidently no less prominent and persistent than No. III of our series. It appears evident that the two are directly equivalent.

Above the siliceous slates in the Penokee system we find a great belt (IV) of magnetitic schists, of the several varieties above indicated, which is unquestionably continuous from Lake Nemakagon in township 44, range 6, west; eastward, nearly to Lake Gogebic, a distance of over eighty miles. In Michigan a succession of layers of strictly similar rocks—both macroscopically and microscopically—overlies the great "Lower Quartzite." In Michigan there are intercalated diorite bands. In Wisconsin these are known only toward the western portion of the belt, where they are, however, very prominent. The peculiar garnetiferous rock of the Penokee section has its exact equivalent in the Michigan magnetic belts, while numerous other peculiar details are the same in the two regions. I should then regard the Penokee magnetic belt as equivalent to Nos. VI to XI of Major Brooks' Marquette series.

Immediately above the magnetic belt (IV) of the Penokee system, or separated from it by a band of black slate (V), which is not known to be sufficiently persistent to deserve consideration in the present connection, is always a covered space without exposure, corresponding to nearly 900 feet in thickness of layers (VI). This would appear to be the equivalent of the belt including the rich ores of Michigan (XIII and XIV), a point of some practical interest.

Above this blank space we find the prevailing rock for a thickness of over 2,000 feet to be a black aphanitic mica slate, which includes, however, bands of quartzite, and thinner ones of diorite, besides which there are blank spaces, the nature of whose underlying rock is a matter of conjecture (VII to XVIII). The black slates and interstratified quartzites are known at points along a belt over twenty miles in length. The equivalents of these members, in the Marquette region, appear to lie from XIV to XVIII of Major Brooks's scheme, where we have quartzite and true clay slate, besides brown to black carbonaceous slates, often distinctly micaceous.

Forming the uppermost members of the Penokee system, we find a great development of mica (biotite) schists, equaling in thickness all of the lower members of the series, and including dark gray, aphanitic kinds, quite coarse, gneiss-like kinds, besides highly quartzose kinds. It is certainly a striking fact, that in the Marquette region the uppermost member (XIX), a mica schist, is the thickest of the whole series, covering often a width, according to the Michigan maps, of over a mile.

The granites which Major Brooks places in his scheme as the youngest of the Penokee Huronian (see this Journal for September, 1876) are merely intrusive patches and veins of small size and area, cutting both the upper mica schists of the Huronian, and the lower gabbros of the Keweenawan system. The gabbros are placed unhesitatingly with the Keweenawan, for the following principal reasons: (1) their general mineral composition allies them closely with the typical diabases of the Keweenaw series while contrasting them with the hornblendic Huronian; (2) when followed along the general trend of the formation, they are found giving place to typical Keweenawan diabase and diabase amygdaloid; (3) similar gabbro occurs interstratified with the undoubted Keweenawan rocks; (4) the gabbro belt cuts diagonally across the Huronian, which it narrows in places to less than one-third the full thickness, thus proving a distinct non-conformity. These gabbros are regarded as of igneous origin, having been one of the first of the great flows of the Keweenaw system, and laid down upon the slightly disturbed Huronian beds.

University of Wisconsin, Dec. 31st, 1878.

ART. L.—*On the Composition of the Cymatolite from Goshen, Mass.*; by A. A. JULIEN.

A MINERAL, pseudomorphous after spodumene, occurs in granite veins of Hampshire County, Mass., which appears to be that first found by Shepard, and by him called cymatolite. The variety at Goshen was analyzed by Burton, and, on the ground of his results, has been assigned to pihlite. A specimen, identical in physical characters with the mineral of Shepard, has yielded me the following composition:

		Oxygen.
Water	2·58	2·29
Nitrogenous organic matter	·43	
Potash	8·38	1·42
Soda	2·57	·66
Lithia	·09	·05
Lime	·48	·14
Magnesia	·75	·30
Manganous oxide	·18	·04
Ferric oxide	1·66	·49
Alumina	24·38	11·38
Silica	58·11	30·99
	99·61	

These new results, corresponding by the old system to the formula

$$(\tfrac{1}{3}(\tfrac{1}{2}\dot{H}+\tfrac{1}{2}\dot{K}\,.\,\dot{Na})^3+\tfrac{2}{3}\dddot{Al})\ddot{Si}^2,$$

induced me to propose a new name, *Aglaite* (Engineering and Mining Journal, April 7, 1877), but I have since inclined to the belief that the material is the same as that first studied by Shepard and Burton. It is therefore now presented as an independent species, under the original name, cymatolite, but it seems worth while to retain the name aglaite for application to the peculiarly brilliant and micaceous variety found at Goshen. In the coming volume of the Annals of the New York Academy of Sciences, I shall give a full discussion of the composition of this mineral, and of its interesting association with spodumene, killinite, œrstedite, autunite, etc.

ART. LI.—*The relations of the Volumes of Solutions of Hydrated Salts to their Water of Composition*; by RICHMOND J. SOUTHWORTH, M.D.

THE object of the experiments, the result of which is stated in the accompanying table, was to test this

Theorem: If a hydrated salt be dissolved in a given volume of water, the volume of the solution will exceed the original volume of the water by a bulk equal to the bulk of saline water contained in the salt dissolved.

The expression *saline water* is used here to signify all the molecules of water contained in the salts, whether they exist in combination as bases, or as water of crystallization. First, the weight in grams of the salt used that contained one cubic centimeter of water in its composition was determined by dividing the atomic weight of the salt by the atomic weight of its saline water, both weights being expressed in grams, the quotient gave the weight, having one cubic centimeter of saline water. As an example: Ferrous sulphate ($FeSO_4$, $7H_2O$) has an atomic weight of 278. Its 7 molecules of saline water have an atomic weight of 126. $\frac{278}{126}$ grams=2·206 the weight of this salt having one cubic centimeter of water in its composition.

Second: The quantity of salt determined by this method to contain one cubic centimeter of saline water was weighed to the nearest centigram, and then dissolved in 90 c.c. of water in a graduated tube of 100 c.c. capacity divided in one-half cubic centimeters. For instance, 2·20 grams of $FeSO_4$, $7H_2O$, were dissolved in 90 c.c. of water at the temperature of 15·5° Centigrade when the volume of the solution equalled 91 c.c.: 2·20 grams more of the salt were added to this solution, and the volume rose to 92 c.c. This process was continued till 22·06 grams of the salt, containing 10 c.c. H_2O, were dissolved in 90 c.c. of water, when the volume of the solution reached 100

c.c. In each of the steps, and in the final result, this experiment agreed with the theorem. This method was pursued where the first experiment with a salt showed a close agreement with the theorem. In those cases where there was a disagreement between the calculated volume and the observed volume of the solution, the weight of salt required to raise the volume of the solution one cubic centimeter was determined by direct experiment. For instance, barium chloride, with the formula ($BaCl_2.2H_2O$) by calculation contained one cubic centimeter of H_2O in 6·777 grams, but the quantity required to raise the volume of the solution one cubic centimeter was 3·89 grams. If the specimen of barium chloride used contained $4H_2O$, the experiment would give a result agreeing with the terms of the theorem.

Salt used.	By calculation.	By experiment.
$Na_2CO_3.10H_2O$	1·588	1·59
$Na_2SO_4.10H_2O$	1·788	1·63
$Na_2SO_4.H_2SO_4.3H_2O$	4·083	3·25
$Na_2O2B_2O_3.10H_2O$	2·122	2·12
$Na_2HPO_4.12H_2O$	1·591	1·59
$BaCl_2.2H_2O$	6·777	3·89
$SrCl_2.6H_2O$	2·468	2·47
$MgSO_4.7H_2O$	1·954	1·95
$ZnSO_4.7H_2O$	2·277	2·28
$NiSO_4.7H_2O$	2·228	2·23
$FeSO_4.7H_2O$	2·206	2·2
$CuSO_4.5H_2O$	2·771	2·77
$Al_2(SO_4)_3.18H_2O$	2·058	2·06
$AlK(SO_4)_2.12H_2O$	2·196	2·2
$AlNH_4(SO_4)_2.12H_2O$	2·099	2·1
$CrK(SO_4)_2.12H_2O$	2·31	2·31

The first column of the table gives the formulæ of the salts according to the last American edition of Fownes's Chemistry. The second column gives the weight in grams that contains one cubic centimeter of saline water, according to the formula. The third column gives the weight in grams found by experiment to increase the volume of the solution one cubic centimeter. An examination of the table will show a close agreement between the results of calculation and experimentation, with the exception of barium chloride, which has been referred to, and the acid sodium sulphate. The disagreement between the calculation and observation in this instance may possibly be explained by the salt decomposing in the act of dissolving, separating into sodium sulphate, which is dissolved, and hydrogen sulphate which unites with the water. This would agree with the strong acid reaction of the solution.

So far as the salts used in these experiments are concerned, the theorem stands the test of experiment, and is demonstrated to be true. In explanation of the changes that occur when a hydrated salt is dissolved in pure water, it may be assumed that the salt is decomposed, separating into an anhydrous portion and saline water, the former going into solution and the latter uniting with the solvent water, increasing its volume.

Yonkers, N. Y., Jan. 31st, 1879.

ART. LII.—*Analysis of the Tetrahedrite from Huallanca, Peru*; by W. J. COMSTOCK. Contributions from the Laboratory of the Sheffield Scientific School, No. LV.

IN this Journal for April, 1878, there is given a short extract from an article in the London Mining Journal by Mr. Henry Sewell, F.R.G.S., describing the mineral caves of Huallanca, Peru. Mr. Sewell states that these silver-producing caves are situated upon the eastern flank of the Peruvian Andes at an altitude of 14,700 feet above the sea, and 4000 feet above the town of Huallanca. The mass of the argentiferous ores consists of the mineral tetrahedrite; these ores contain about 800 ounces of silver to the ton. The mineral is in part obtained from huge cavities, some of them twenty-five or thirty feet long, and as much deep. Mr. Sewell describes the crystals as occurring in such abundance on the walls of these caves, that "millions" of them are destroyed by the picks of the miners.

Some specimens from this locality were presented to the Yale College Museum by Mr. Sewell; the crystals are large and brilliant and in one case have a length of about two inches. They have the usual characteristic tetrahedral form. I have analyzed a portion of one of the crystals, and have obtained the following results: Specific gravity =4·7.

	I.	II.	Mean.
S	26·69	26·79	26·74
Sb	9·08	9·04	9·06
As	13·35	13·62	13·49
Ag	3·95	3·77	3·86
Cu	39·01	39·16	39·09
Fe	5·46	....	5·46
Zn	2·14	....	2·14
	99·68		99·84

I give below the amount of sulphur required to combine with each of the metals and also the atomic ratio.

Sulphur calculation.			Atomic ratio.		
Sb	3·56	S	·8356	·8356
As	8·57	Sb	·0743	·2528
Ag	·57	As	·1785	
Cu	9·87	Ag_2	·0179	·4567
Fe	3·12	Cu_2	·3083	
Zn	1·06	Fe	·0975	
		Zn	·0330	
	26·75			

From the above is obtained the ratio

$$\cdot 2528\ R_2S_3 + \cdot 9134\ RS, \quad \text{or} \quad R_2S_3 + 3\cdot 6\ RS.$$

The method employed in the analyses was that of H. Rose, except in the determination of the arsenic. On account of the difficulty in weighing magnesium ammonium arseniate, after separating by means of magnesia mixture and alcohol the precipitate was dissolved in dilute hydrochloric acid, reduced by sulphurous acid, the excess of the latter was evaporated off, and the arsenic precipitated and weighed as sulphide. A slight amount of free sulphur was dissolved out by carbon-disulphide.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Determination of Fusing Points.*—Commonly fusing points are determined by placing a fragment of the substance in a thin glass tube attached to the bulb of the thermometer, and then placing both in water gradually heated until the substance melts, the temperature being then noted. Terreil proposes to modify this method by melting the substance separately and then by means of a glass rod a single drop is deposited on the thermometer bulb, which is then placed above a gas flame at such a distance that the heating is very slow. The temperature is read at the instant the substance melts, and the whole is allowed to cool and the solidifying point noted; this operation being repeated several times. In this method the phenomena of surfusion disappear, the fusing and solidifying points coinciding sensibly. For fusing points above 100° the thermometer should have a larger bulb, so that it changes temperature slowly.—*Bull. Soc. Ch.*, II, xxxi, 155, Feb. 1879. G. F. B.

2. *On Chromium, Manganese, Iron, Nickel and Cobalt Amalgams.*—Moissan has shown that when a concentrated solution of chromous chloride in water is agitated with a pasty sodium amalgam there is produced a chromium amalgam. After removal of the excess of sodium by boiling in water for an hour, the amalgam is obtained as a liquid, less fluid than mercury, covering itself on standing in the air with a black layer of oxide, decompo-

ing slowly in dry air, more rapidly in presence of water. Heated to above the boiling point of mercury in a current of hydrogen, it leaves a residue of metallic chromium, as a black amorphous mass, which heated on platinum foil becomes incandescent and leaves a residue of green chromic oxide. The chromium made by this process is not acted on by boiling concentrated sulphuric acid, but dissolves in dilute sulphuric acid and in strong nitric containing nitrous acid. Hydrochloric acid when hot attacks it slowly, evolving hydrogen. The amalgams of manganese, of cobalt, and of nickel which were obtained in this way have a pasty consistence and contain more of the metal than the chromium amalgam. Manganese amalgam was also obtained by electrolysis by decomposing a solution of manganous chloride, using a negative electrode of mercury. When distilled at 440° pulverulent manganese was obtained, which became incandescent when treated with a few drops of fuming nitric acid, and which decomposed water slowly at ordinary temperatures, rapidly at 100°. Since the production of this amalgam polarizes the electrodes, it is probable that the richness of the amalgam is definite for a given battery.—*Bull. Soc. Ch.*, II, xxxi, 149. G. F. B.

3. *On Chromates and Dichromates.*—SCHULERND at Kolbe's suggestion, has examined the conditions under which dichromates of the metals are formed. He examined the salts formed with barium, lead, mercury, silver, thallium and lithium, using precipitation for their preparation in all but the latter case. With barium, lead, and mercury, only the normal chromate $R''CrO_4$, could be obtained, either by precipitating with potassium dichromate or by evaporating with excess of chromic acid. With silver, thallium and lithium on the other hand, dichromates were readily obtained. Silver nitrate is precipitated by potassium dichromate, yielding a dark red crystalline powder of silver dichromate, $Ag_2Cr_2O_7$. Thallous carbonate gives thallous chromate when precipitated by potassium chromate and thallous dichromate when thrown down by the dichromate in acid solutions. The chromate and dichromate of lithium are well crystallized salts, the former having a pure yellow, the latter a dark orange, almost black color. Each has two molecules of crystal water, both are deliquescent, and lose their crystal water at 130°.—*J. pr. Ch.*, II, xix, 36, Jan. 1879. G. F. B.

4. *On the Purification of Mercury.*—BRÜHL has proposed to use chromic acid for the purpose of purifying mercury, and has freed twenty-five kilograms of mercury from Wood's fusible metal with which it was contaminated, in two hours by its means. Five grams of potassium dichromate are dissolved in a liter of water, a few cubic centimeters of sulphuric acid are added, and the mercury is shaken with its own volume of the solution. The metal divides into small globules, a little red chromate being formed. The agitation is continued until this red powder has disappeared and the solution has become green. By a strong current of water, a gray powder of metallic oxides is washed away, and the process is re-

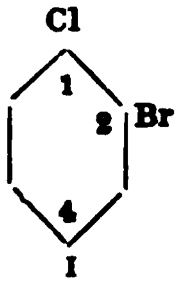
peated if necessary. The accumulated mercury of five years of the author's laboratory, some of which had been used to amalgamate zincs and was semi-solid, was completely purified in an afternoon in this way. The loss is small, two kilograms of mercury, after three treatments with 100 c.c. of the acid solution, washing, heating to 150° and weighing, lost only 10 grams.—*Ber. Berl. Chem. Ges.*, xii, 204, Feb. 1879. G. F. B.

5. *On Eikosylene, a hydrocarbon from the Paraffin of Brown coal.*—LIPPMANN and HAWLICZEK have examined the chlor-derivatives of paraffin from various sources, in order to determine the molecular weight of these bodies. In the first place, the paraffin of commerce was found uniformly to contain oxygen, from which it must be freed by repeated treatment with sodium in a sealed tube heated to 250°. Thus purified the brown-coal paraffin had, after recrystallization from alcohol, a melting point of 37° C. To produce the chloride it was at first treated with twice its weight of phosphoric chloride diluted with carbon tetrachloride, and heated in a sealed tube to 215°. But subsequently it was melted in a balloon at 170°, and the phosphoric chloride added as required through a wide tube, in the necessary quantity. The residue of the operation was liquid. After washing with water, it was separated from the unacted-on paraffin by cooling to —15° C. and fractionated in vacuo. An oily liquid was obtained in this way which boiled at 225° to 230° and afforded on analysis the formula $C_{20}H_{39}Cl$, having evidently been produced from the body $C_{20}H_{40}Cl$, by loss of HCl. Distillation at the ordinary pressure decomposed it further, $C_{20}H_{39}Cl = C_{20}H_{38} + HCl$. The hydrocarbon thus obtained boiled at 314°—315°, and the authors propose for it the name eikosylene. Its specific gravity is 0·8181, but its vapor density could not be determined, since it totally decomposed at 440°. It acts like an olefine, combining actively with halogens, forming a chloride $C_{20}H_{38}Cl_2$ and a corresponding bromide. It belongs to the acetylene series, being homologous with cetylene $C_{16}H_{30}$ its highest member. The evidence that the hydrocarbon $C_{20}H_{42}$, mixed perhaps with others of higher boiling point, constitutes the paraffin of brown coal, seems well established.—*Ber. Berl. Chem. Ges.*, xii, 69, Jan. 1879. G. F. B.

6. *On the Transformation of Starch into Dextrose in the Cold.*—It is known that starch is slowly transformed into dextrose when boiled for a long time with water. RIBAN has made some observations which seem to show that the same result may take place in the cold, though much more gradually. A solution made by boiling one part of finely divided starch in 100 of water saturated with salt, and filtering, is imputrescible and may be preserved for a long time. After a year the author's solution appeared less sensitive to iodine, and after three or four years, it was not colored by this reagent. It was neutral, limpid, contained no trace of any organized ferment, reduced energetically the copper test and was browned by alkalies. Determined by the copper test, every 100 c.c. contained 0·111 gram dextrose; but using ferricyanide of potas-

sium which is not affected by dextrin, 100 c.c. contained 0·102 gram. Hence a mixture of nine-tenths dextrose and one-tenth dextrin was formed from the starch. The solution, in a tube 200 mm. long rotated to the right; $a_D = +0{\cdot}15°$. The author calls attention to the importance of this transformation of starch in the cold, without a ferment, in the physiology of vegetable growth.—*Bull. Soc. Ch.*, II, xxxi, 10, Jan. 1879. G. F. B.

7. *On the Structure-formulas of Aromatic Compounds.*—The present method of representing aromatic isomers is either graphic, by the use of the letters *p*, *m*, or *o*, standing for para, meta or ortho, or by using figures to represent the positions. Thus the structure of the compound C_6H_3ClBrI may be represented by



or by $C_6H_3\overset{1}{Cl}\overset{2}{Br}\overset{4}{I}$. WROBLEVSKY proposes a simpler mode of expressing the position of the replacing atoms, writing the formula differently according as the two replacing atoms are symmetrically or unsymmetrically arranged or occupy neighboring positions. Thus, for example, the chlorine derivatives of benzene may be written in this way so as to express all the facts in a much less space:

Empirical.	Symmetrical.	Unsymmetrical.	Neighboring.
$C_6H_4Cl_2$	$C_6H_2ClH_2Cl$	C_6H_3ClHCl	$C_6H_3Cl_2H$
$C_6H_3Cl_3$	$C_6HClHClHCl$	$C_6H_2ClHCl_2$	$C_6H_2Cl_3H$
$C_6H_2Cl_4$	$C_6HCl_2HCl_2$	$C_6HClHCl_3$	C_6HCl_4H

So if the positions 1, 2, 3, 4 in the benzene ring be filled by chlorine, bromine, iodine and hydrogen, the formulas will be $C_6H_2ClBrHI$, $C_6H_2BrClHI$, $C_6H_2IClHBr$, $C_6H_2BrIHCl$, $C_6H_2ClBrIH$, $C_6H_2BrClIH$, etc. In the first of these formulas the Cl is symmetrical with the I, is in the neighboring position with the Br, while the Br and I are unsymmetrically situated. So the naphthalene derivative which has I in the position 4 and Cl in 6, may be written $C_6HClH_2(C_4IH_2)$ or $C_6H_2ClH(C_4H_3I)$.—*Ber. Berl. Chem. Ges.*, xii, 161, Feb., 1879. G. F. B.

8. *On the Phthalein of Orthocresol.*—FRAUDE has extended the production of Baeyer's phthaleins by producing the phthalein of orthocresol $C_6H_4\left\{\begin{array}{l} CO\text{---}C_6H_3\left\{\begin{array}{l}OH\\CH_3\end{array}\right.\\ CO\text{---}C_6H_3\left\{\begin{array}{l}OH\\CH_3\end{array}\right.\end{array}\right.$. For this purpose two parts cresol, three of phthalic oxide and two parts of stannic chloride were heated together to 120° for 8 to 10 hours. The cresol unacted on was removed by a current of superheated steam, the mass was dissolved in solution of soda, and precipitated by hydrochloric acid, this process being repeated once or twice. Solution in alcohol, decolorization with bone black, and dilution with

water, gave the phthalein in flesh-red crusts. The diacetyl, dibenzoyl, dinitro, and dibrom derivatives are described, as also mono-orthobromcresol-phthalein and its barium compound. By heating cresol and phthalic oxide with sulphuric acid, methyloxyanthraquinone is produced; and this heated to 200° C. with excess of potash yields methylalizarin. The phthalins, phthalidins and phthalideins corresponding to the phthaleins of orthocresol are described in the same memoir.—*Ber. Berl. Chem. Ges.*, xii, 237, Feb. 1879. G. F. B.

9. *Baryta and Strontia.*—The fact that the compounds of baryta and strontia occur in nature in very different associations has long been recognized by mineralogists, and in the December No. of the Ann. de Chim. et de Phys., M. Dieulafait has published an interesting paper which offers a plausible explanation of this difference of occurrence. In the first place the author established the fact that both baryta and strontia are present in sensible quantities in the feldspars and micas of the older crystalline rocks. He examined feldspars from fifty-four different localities, and also micas in numerous associations, besides eighty specimens of granites in mass, sixty of gneiss and many of syenite, and in all of these he discovered not only lime but also strontia and baryta. From various circumstances, but especially from the association of barite with metallic sulphides in mineral veins it is inferred that the alkaline earths are dissolved from the rocks as sulphides, and the author promises us in a future paper a discussion of the nature of the sulphuretted solvent. It is next argued, from the known reaction of the carbonic dioxide and oxygen of the atmosphere on a solution of strontic and baric sulphides, that such a solution while flowing off in contact with the air would deposit, in the first place, the carbonates of these bases nearest to the source, and, subsequently at a greater distance the sulphates, thus determining a separation between the two groups of minerals. Again the sulphate of strontia, being more soluble than the sulphate of baryta—and, according to the author, existing relatively in much larger quantities in the crystalline rocks—would be to a much greater extent washed down by the running streams; collecting in salt basins, and in the layers of gypsum, which are deposited in these basins; while on the other hand the more insoluble sulphate of baryta would be left behind. Lastly the strontium reduced from the condition of sulphate to sulphide by the organic matter in the gypsum beds—and thus becoming very soluble—again undergoes the same reactions in contact with the air to which we have just referred, giving rise first to an insoluble carbonate and a solution of a polysulphide and then to a sulphate and free sulphur. Thus are explained the facts that celestine is found almost always in beds of gypsum and associated with crystals of sulphur. It is argued in conclusion that if the circumstances of the occurrence of celestine and barite at the present day differ so widely that this arises solely from the fact that the strontium compounds found in salt-beds are in the second stage of their development, while the corresponding

compounds of baryta left in the veins of crystalline rocks are in the first stage; and that in spite of all present differences of occurrence and association, the baryta and strontia minerals may be traced to the same origin in the old crystalline rocks of the earth's crust. J. P. C.

11. *The illumination of gases by Electric discharges.*—Professor E. WIEDEMANN continues his work upon the nature of spectra, and shows that a gas having a temperature far below 100° C. can be illuminated by electrical discharges. By means of a small calorimeter, in connection with a peculiarly arranged exhaustion tube, Professor Wiedemann was enabled to arrive at the amount of heat communicated to the gas under examination at different pressures. The temperature of the gas in the beginning was in the neighborhood of 20° C. and reached a maximum of from 80°–90° by means of the discharges from a Ruhmkorf coil, even at this temperature the gas was brilliantly illuminated; and the temperatures of 62°–70° was not found to be the lowest at which the gas was illuminated.

The illumination of the gas at such low temperatures is produced, Professor Wiedemann thinks, by an exaltation of the living force of the oscillatory movements of the ether envelopes. The electrical discharge calls forth this action independently of the increase of molecular movement which results from the increase of temperature.—*Annalen der Physik und Chemie*, No. 2, 1879, p. 298. J. T.

12. *A new current interrupter.*—Dr. F. NIEMOLLER describes an extremely simple and efficacious form of interrupter. To the middle of a wire stretched horizontally is attached a platinum point which touches the surface of mercury in a little containing vessel. The current is led over this wire, and a magnet over the half of the wire through which the current is conducted serves to maintain the vibrations of the wire. The number of vibrations can be readily modified by changing the length of the wire, and as high a number as 1000 breaks in a second can be obtained. By passing an intermittent current over the wire it can be set in vibration without the intervention of mechanical means. This happens when the fundamental note of the string is in unison with the pitch of the interrupter.—*Annalen der Physik und Chemie*, No. 2, 1879, p. 302. J. T.

13. *The dimensions of Molecules.*—R. RÜHLMANN, by means of the formula

$$\lambda = \frac{1}{\sqrt{2}} \frac{\delta^3}{\pi\rho^2},$$

in which λ represents the mean path of the molecules, δ the mean distance between the molecules and ρ the radius of their sphere of action, calculates the sum of the molecular sections. Since $N\delta^3 = 1$, if N represents the number of molecules in the unit of volume, we have

$$\frac{N\rho^2\pi}{4} = \frac{1}{4\sqrt{2}\lambda}$$

According to Avogadro's law equal volumes of different gases under the same pressure and temperature contain the same number of molecules, the ratio of the sum of the sections is the ratio of the section of the molecules themselves. Bearing this in mind, one is justified, since the mean accuracy of the numbers found can be depended upon within eight per cent, in regarding, in the following tables, the numbers found for the two-atom molecules, with the exception of chlorine, hydrogen and hydrochlorine, as equal among themselves, and the section of the hydrogen molecules as one-half and that of chlorine as twice as great. The three-atom molecules of CO_2, of N_2O, of H_2O and of H_2S have the same molecular sections and stand in relation to the large number of two-atom gases as 3 : 2 or as the number of atoms. To this law SO_2 is an exception, since its molecular section is the same as that of chlorine. H_3N and HCl take a decided position. Possibly CH_4 can be included with them, since the mean of these three numbers is related to the molecular section of the two-atom molecule nearly as 4 : 3. One is also tempted to regard the molecular sections of C_2H_4, of SO_2, of chlorine, and CH_3Cl as equal and as double that of the two-atom molecule.

The following table includes the sum of the molecular sections of each gas in a cubic centimeter, expressed in square centimeters.

	H_2	9100	approximately	9000	$= 1 \times 9000$
Two-atom	O_2	16900	"	18000	$= 2 \times 9000$
	N_2	18000	"	18000	
	CO	18200	"	18000	
	NO	18700	"	18000	
Three-atom	CO_2	26700	"	27000	$= 3 \times 9000$
	N_2O	26800	"	27000	
	H_2O	26400	"	27000	
	H_2S	28600	"	27000	
	CH_4	21600	"	24000	$= \frac{8}{3} \times 9000$
	H_3N	23400	"	24000	
	HCl	24200	"	24000	
	C_2H_4	31600	"	36000	$= 4 \times 9000$
	SO_2	36700	"	36000	
	Cl_2	36700	"	36000	
	CH_3Cl	39300	"	36000	

Professor Rühlmann also gives the following values of ρ.

For nitrogen molecule $= 34 \cdot 10^{-9}$ cm.
For carbonic dioxide molecule $= 16 \cdot 10^{-9}$ cm.
For hydrogen molecule $= 41 \cdot 10^{-9}$ cm.

At 0° and 760 mm. pressure a cubic centimeter holds nearly 100 trillions of gas molecules. Under these conditions the molecules themselves fill nearly the three-thousandth part of the space occupied by the gas. The absolute weight of a hydrogen molecule is represented by $15 \cdot 10^{-23} g$ and the specific weight as 360.—*Beiblätter Annalen der Physik und Chemie*, 1879, No. 2, p. 57.

J. T.

14. *American Chemical Journal;* edited, with the aid of Chemists at home and abroad, by IRA REMSEN, Professor of Chemistry in the Johns Hopkins University. Vol. i, No. 1, 76 pp. 8vo. Baltimore, April, 1879.—The establishment of this American Chemical Journal is an event of great importance to the science of the country. The Journal could not be in better hands; for the editor, Professor Remsen, is both a man of thorough learning in his department, and an able and hard-working investigator. The number just issued compares well in its memoirs with the best of other lands. The subjects of some of these are: the Complex inorganic acids, by Wolcott Gibbs; Nitrogen iodide, by J. W. Mallet; on Lockyer's hypothesis that the so-called Elements are compound bodies, by C. S. Hastings; a New Volumetric method of determining Fluorine, by S. L. Penfield; on the Oxidation of substitution-products of aromatic Hydrocarbons, by Ira Remsen and M. W. Iles. The Journal is to be issued every other month; the subscription price is three dollars a year.

II. GEOLOGY AND NATURAL HISTORY.

1. *Fossil Forests of the Volcanic Tertiary Formations of the Yellowstone National Park;* by W. H. HOLMES. (Bull. U. S. Geol. and Geogr. Survey, Vol. v, No. 1.)—The volcanic Tertiary deposits (tufas, etc.) of the Yellowstone region have a thickness of more than 5,000 feet. They contain silicified trunks of trees in many places. Mr. Holmes describes particularly a section on the north face of Amethyst Mountain, in which upright trunks occur at many levels, along with others prostrate, from near the foot to the highest stratum. On the steeper part "rows of upright trunks stand out like the columns of a ruined temple," and on the slopes lower down, the petrified trunks fairly cover the surface. Some of the prostrate trunks are fifty to sixty feet long and many are five to six feet in diameter. The upright trunks are occasionally thirty feet high; and one twelve feet high was ten in diameter, and its bark was four inches in thickness. There are also leaves and stems, and Lesquereux has identified among them *Aralia Whitneyi*, *Magnolia lanceolata*, *Laurus Canariensis*, and new species of *Tilia*, *Fraxinus*, *Diospyros*, *Cornus*, *Pteris* and *Alnus*.

2. *Fruit-bearing branch of Cordaites from Cannelton, Pennsylvania.*—In the Proceedings of the American Philosophical Society for April, Professor Lesquereux has described a specimen of Cordaites bearing fruit, collected by Mr. I. F. Mansfield at Cannelton. It is a bent or pendent branch twelve centimeters long and nearly one and a half broad, having the fruit arranged spirally in a loose strobile-like way. The winged nut or fruit is oval, 3 centimeters long, 2·3 broad, and broadly obtuse and entire at top. It indicates, according to Mr. Lesquereux, that the Cordaites are allied to the Cycads, or rather are an antecedent type intermediate between Cycads and Conifers.

3. *Annual Report of the Wisconsin Geological Survey, for the year* 1878; by T. C. CHAMBERLIN, Chief Geologist. 52 pp. 8vo. Madison, Wis., 1879.—This Report contains observations on the recent glacial drift of the Alps, and on the bearing of the facts on Wisconsin surface geology, by Professor Chamberlin.

4. *The Woodland Caribou or Reindeer* (*Rangifer Caribou*) *from the Lœss of Iowa.*—Dr. LEIDY announces the discovery by Professor Witter, in the lœss of Muscatine, Iowa, of fragments of the upper and lower jaws and some other bones of this species. From the same locality Professor Witter collected the shells *Helix striatella*, *H. fulva*, *H. pulchella*, *H. lineata*, *Pupa muscorum*, *P. Blandi*, *P. simplex*, *Succinea obliqua*, *S. avara*, *Limnea pumilis?* and *Helicina occulta.*—*Proc. Acad. Nat. Sci. Philad.*, 1879, p. 32.

5. *Amber and Asphaltum from Vincenttown, New Jersey.*—Mr. E. GOLDSMITH reports these minerals from the Ash Marl of the Cretaceous, a layer above the Green-sand. The mass of asphaltum weighed 100 pounds. The amber is stated to be related to the variety of succinite called Krantzite by C. Bergemann. Unlike ordinary amber its specific gravity is less than 1, and it fuses to a mobile liquid. This amber is of occasional occurrence in the New Jersey Cretaceous; "sometimes hundreds of tons may be looked over without finding a single piece; and at other times enough has been found to fill a barrel within a day."—*Ibid.*

6. *Guides for Science-Teaching.* — This is the title of a few primers, published by the Boston Natural History Society, and meant to supplement and enforce lectures given by members of that Society to Teachers of the Public Schools of Boston. These teachers are all required to give to their pupils a certain number of *object lectures.* But who shall teach the teachers, and wherewithal shall they be taught? Well, a few public-spirited ladies supplied the material means for a free course of instruction to five or six hundred teachers, and two or three individuals contributed their knowledge and experience, and carried into execution an admirable plan. The substance of the lessons of this course, given by Mr. Hyatt and Professor Goodale, is exhibited and preserved in these primers. The plan was to speak of nothing which was not shown, and not only shown but placed in the hands of the auditors. And this not by specimens passed round, and so reaching most of the pupils after the discourse had passed on to something else; but each hearer was supplied with a whole suite of the objects lectured on, to examine at the moment and to take home for further examination and review.

The first lesson, by Mr. Hyatt, is *About Pebbles.* A tray placed before each pupil holds a small quantity of fresh-broken rock, a weathered piece with worn angles, a complete and rounded pebble, a spoonful of gravel and another of sand. With these, and with reference to what every one remembers to have seen on shores and beaches, in quarries and stone-yards, and along brooks and roadsides, the lesson proceeds, and the elemental facts are

taught rather by questions asked and by observations incited than by didactic lecturing.

The second primer contains the substance and displays the method of Professor Goodale's course of lessons "*Concerning a Few Common Plants.*" For the first lesson, on a seedling, each of the five hundred auditors, supposed normally to represent a child-pupil, had before him a bean freshly soaked, another the sprouting of which in germination had barely commenced, a third with germination more advanced, a fourth which had developed not only a root below, but the first two leaves above the cotyledons. The discourse opens by the asking of some simple questions, every one of which must be answered by an examination of these objects. The second lesson compares two seedlings, viz. the pea with the bean; the third compares still other and different seedlings; and by this time the pupils have made out the leading facts and ideas of vegetable morphology as it were for themselves. This knowledge is extended in a similar way, and by the comparison of various leafy shoots, to the consideration of "how the parts of plants help one another." Later these parts, roots, stems, and leaves are taken up separately; then the way in which plants feed and grow is taught; then wood is illustrated by small truncheons, blocks variously cut, and veneers, of which each pupil has a set; and the structure and morphology of the blossom is brought out by similar methods. Teachers so taught should be able to give "object lessons" to their young pupils with some success. Those who have not the advantage of such training should send for these primers (costing ten and twenty cents apiece) study them thoroughly, and follow the directions they give.

The third primer, about Commercial and other Sponges, is very good, but different. It begins aright with a bath sponge, and some common reef-sponges to be had cheaply of the wholesale druggists. But it departs from the normal plan by entering into microscopic details, illustrated by figures, and into an account of sponge-gathering by divers in the Mediterranean and the Gulf of Mexico. A. G.

7. *Function of the Sterile Filament of Pentstemon.*—Dr. LÉO ERRERA, in Belgium, has been investigating two allied Mexican species, viz. *Pentstemon gentianoides* and *P. Hartwegi*, with their varieties, now common in cultivation. Noting the fact that the sterile filament, which belongs to the upper side of the flower, is from near its base, declined upon the lower side of the corolla-tube or throat, he comes to the conclusion that its principal function is to obstruct the access of unwelcome insects to the nectar at the base of the flower. The size of the corolla and disposition of the genitalia is such that only large insects, such as humble bees, which fill the whole cavity, can effect fecundation. The somewhat smaller ones, which would rifle the flower of its sweets without rendering any service, are excluded from the nectar by this bar across the base of the tube. Professor Kerner,

who of late has especially studied the arrangements in flowers for the exclusion of unbidden guests, as he terms them, appears to have anticipated this conclusion in respect to *Pentstemon.* While making observations upon the five forms of these two species which were in cultivation at Brussels, Dr. Errera was surprised to find that only one of them was freely visited by hymenopterous insects: this was a form of *P. Hartwegi*, with mauve-colored corolla. The others, though occasionally tried, were, on the whole, neglected; and he found that this remarkable preference depended not at all upon the abundance or quality of the nectar, nor upon the perfume, nor upon the color of the corolla, except by a coincidence as to the latter; but in the fact, that in all but the mauve-colored form, the curvature of the sterile filament, which obstructed further entrance, was so high in the tube that the tongue of these insects could not reach the nectar at the bottom of the tube. A difference of a millimeter or two in the curvature of the sterile filament or the length of the tube below, determined whether or not the flowers should be fertilized in Belgium.

Errera's paper is published in the 17th volume of the *Bulletin de la Société Royale de Botanique de Belgique*, February, 1879, is preceded by a very detailed dissertation on the structure and fecundation of flowers in general, by himself and M. Gustave Gevaert, occupying 140 pages, 8vo. The motto of the paper is taken from Darwin—"Whoever is led to believe that species are mutable, will do good service by conscientiously expressing his conviction." The authors have expressed theirs, and the grounds of it, with great fullness. A. G.

8. *Revue Mycologique*, is the title of a new periodical, devoted to the study of *Fungi*, under the editorship of M. Roumeguère of Toulouse, published at that city and at Paris (Baillière); the first number, of 44 pages, 8vo, issued in January last. Price 12 francs a year. The leading article is upon the Lichen question, in the light of the recent investigations of Dr. Minks, confirmed by Dr. Mueller of Geneva. Half of this first fasciculus is devoted to notices of recent publications and to mycological news. The editor takes notice of Professor Hitchcock's recent proposition to the microscopists in the convention at Indianapolis, to adopt the $\frac{1}{100}$ of a millimeter as the micrometric unit, and regrets it, on account of the adoption, several years ago, in Europe (upon the proposition of Suringar of Leyden) of the $\frac{1}{1000}$ of a millimeter (denoted by the Greek μ) as the micrometric unit. A. G.

9. *Meehan's Native Flowers and Ferns of the United States*, illustrated by chromolithographs of Prang & Co.—The whole of vol. ii, issued since our last notice, is now before us. The new volume, parts 13 to 24, compares very favorably with the first. The drawings are better; the color-printing at least as good; and the excursions in the letter-press comparatively seldom tempt the reviewer to critical remarks. Such plates as those of *Phaseolus diversifolius*, *Andromeda Mariana*, *Cerastium arvense*, *Helianthus Maximiliana*, and *Echinocatus polycephalus*, even satisfy the

fastidious. Perhaps we should have added *Gaillardia amblyodon* to the list, if we had not placed by the side of it Sprague's figure in the Chloris Bor.-Am., which belongs to some of this artist's early work. We could wish that Meadow Beauty (*Rhexia Virginica*) had a better opportunity to display her charms. We learn that the work will be directly continued in a second series, in which we hope that the success of the enterprise will stimulate still further improvement in the drawings. A. G.

10. *Observations on Several Forms of Saprolegnieæ;* by FRANK B. HINE, B.S.—This is a thesis, submitted for the degree of B.S., at Cornell University, and the pamphlet is an article extracted from the American Quarterly Microscopic Journal, vol. i. It is illustrated by four excellent plates, drawn by the author from nature. The figures and the letter press (20 pages) give a very favorable impression of the author's ability, judgment, and taste. The two latter qualities are shown in his forbearance to give new specific names to forms of which the sexual reproduction is not made out, notwithstanding their apparent difference from described species; and he refrains from proposing a new genus in another case upon a new point of structure which he observed, but which may not require or justify this distinction. An indisposition to introduce new names which may be needless, and therefore encumbering, is a hopeful sign. A. G.

11. *A Popular California Flora, or Manual of Botany for Beginners;* by VOLNEY RATTAN, Teacher of Natural Sciences in the Girls' High School, San Francisco. (S. Francisco: Bancroft & Co. 1879).—The schools of California have long been needing an aid like this by which they may study the flowers which abound around them, and which in spring make gay the whole face of the country. This book, of 103 pages, in the form of "How Plants Grow," is the first and a laudable attempt to supply a pressing want. It is a first part only, including the Polypetalæ and Gamopetalæ, and a second part will complete the work. It is very well compiled from the Botany of California and the Synoptical Flora of North America; and it is restricted to the plants of the San Francisco region, extending north to Mendocino County, south to Monterey, and west to the foot-hills of the Sierra Nevada. The *Umbelliferæ* and *Compositæ* are omitted because "too difficult for beginners." In a second edition these might be added, and rendered about as easy as the rest, with a skillful popular presentation, for which we could give the worthy author some hints. A. G.

12. *Halosphæra, eine neue Gattung grüner Algen aus dem Mittelmeer;* by Dr. FR. SCHMITZ.—The present paper, taken from the first volume of Mittheil. aus der Zoologischen Station at Naples, gives an account of a minute floating Alga, which is common in the Bay of Naples from January to April, and is vulgarly known as "punti verdi." Pelagic Algæ are little known, and the present species offers several points of interest. It occurs in the form of isolated spherical cells which float on the open sea, without any independent power of locomotion. The cell-contents divide into very numerous daughter-cells which produce zoöspores

by secondary division. The latter are of an unusual form, being conical, with the two long cilia attached to the base instead of to the apex of the cone. The development of the zoöspores is unknown.

In this connection we may mention a second paper by the same author on *The Green Algæ of the Bay of Athens.* He considers the little known *Acrocladus mediterraneus* of Nægeli to be merely a peculiar condition of the common *Cladophora pellucida* of Kützing, and not the young of *Acetabularia*, as was supposed by Zanardini. He describes two new species of *Siphonocladus*, a genus midway between *Valonia* and *Cladophora*, resembling the latter in ramification but differing from it in the transverse cell-walls not being complete, but only partial as in *Valonia*. At the end of the paper are some remarks on the relations of different genera of green Algæ, which constitute the *Siphonocladiaceæ.*

G. W. F.

13. DR. W. G. FARLOW, for the past five years Assistant Professor of Botany at the Bussey Institution, Harvard University, has been appointed Professor of Cryptogamic Botany in the University proper. This is the first professorship in this important and difficult department established in this country. The laboratory for instruction and research in the lower Cryptogamia is now established at Cambridge.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Intra-Mercurial Planet.*—Careful search was made at the Royal Observatory, Greenwich, and other places for the transit of the supposed intra-Mercurial planet over the Sun, which, according to an orbit calculated by Dr. Oppolzer, of Vienna, might take place in the morning of the 19th of March last. Nothing, however, was seen of it—a result which cannot surprise those accustomed to astronomical observations, and able to appreciate the great uncertainty of the data on which the calculations were founded, several of the observations (among which we, for our part at least, must include the famous one by the Orgères physician, M. Lescarbault, in 1859) being probably of some spot on the Sun or else altogether apocryphal. With regard to the objects seen during the total solar eclipse last July, Dr. Oppolzer's orbit did not take in either of them.—*Athenæum*, April 12.

2. *Geological Society of London.*—At the recent annual meeting of the Geological Society, the Wollaston gold medal was awarded to Professor Bernard Studer, "the father of Swiss geology;" the Murchison medal to Professor M'Coy, of Melbourne; the Lyell medal to Professor E. Hébert, of Paris; the Bigsby medal to Professor E. D. Cope, of Philadelphia; the balance of the Wollaston Donation Fund to Mr. Samuel Allport; the proceeds of the Murchison Geological Fund to Mr. J. W. Kirkby; a moiety of the balance of the proceeds of the Lyell Fund to Professor Alleyne Nicholson, and the other moiety to Dr. Henry Woodward, F.R.S. —*Nature*, March 13.

3. *Geological Survey of the Territories of the United States.*—The plan proposed by the Committee of the National Academy of Sciences for the scientific surveys of the United States Territories (this Journal, January, 1879, p. 78), was accepted by Congress, just at the close of the last Session, (March 9th), so far as it relates to the Geological Survey. The position of Director of the Survey has been given to Mr. Clarence King, who has recently brought the Survey of the 40th Parallel to a successful completion. Congress has also appropriated a sum of twenty thousand dollars for the final completion of each of the three Surveys, which have been carried on up to this time under Lieut. Wheeler, Dr. F. V. Hayden, and Major Powell.

4. *Gold Medal of the Astronomical Society.*—The Council of the Royal Astronomical Society of England has awarded the gold medal of the society for this year to Professor Asaph Hall of Washington. In the address of the President, Lord Lindsay, on presenting the medal, a detailed statement is made of Professor Hall's many and valuable contributions to astronomical science, with special reference to the most important of these: the discovery of the satellites of the planet Mars.

5. *Paris Academy of Sciences.*—The "Serres" Prize for 1878 has been awarded by the Academy of Sciences, for the best work in embryology, to Alexander Agassiz, of Cambridge. This is the first time the prize has been given. The value of the prize is 7500 francs.

Prof. J. Lawrence Smith has recently been elected a Corresponding Member of the Academy, in the place of Sir Charles Lyell.

6. *Memoirs of the Museum of Comparative Zoology.*—The first part of No. 1, vol. vi, of the Memoirs of the Museum of Comparative Zoology at Cambridge, Mass., has just been published. It contains a portion (288 pp.) of a work on the Auriferous Gravels of the Sierra Nevada of California, by Professor J. D. Whitney. The remainder of the volume will be ready in a few months.

7. *Report of the Observations of the Total Solar Eclipse, July 29th,* 1878, *made at Fort Worth, Texas;* edited by Leonard Waldo, Assistant of the Observatory of Harvard College. 60 pp. 4to, with 4 plates. Cambridge, 1879.—A notice of this report will be given in another number.

OBITUARY.

Frank Howe Bradley died, from the falling of a bank in a gold mine, near Nacoochee, Georgia, on the 27th of March. Mr. Bradley was born at New Haven, Connecticut, on the 20th of September, 1838. He was graduated at Yale in 1863, and afterward pursued special studies in natural science in connection with the Sheffield Scientific School. But still earlier, his tastes had led him to the study of geology, and in 1857, before he had passed his nineteenth birthday, he had by his discoveries at Keeseville added a new trilobite to the known fauna of the New York Potsdam sandstone, which till then had afforded no animal remains

but Lingulæ and Scolithi; and had proved by imperfect specimens the existence also of Crinoids and Pleurotomariæ in the same beds. This discovery was announced that year at the meeting of the American Association at Montreal, and made the subject of an article in this Journal in 1860. After his graduation at Yale, much of his time was spent in the field making collections of fossils, and, for more than a year, at Panama and its vicinity where he obtained large collections of corals and other specimens in zoology, partly for the Yale Zoological Museum. During the year 1867 he was assistant geologist in the survey of Illinois, and, in 1869, in that of Indiana. The Indiana report for that year contains a valuable chapter by him, treating especially of the Vermilion County Carboniferous rocks. Two species of land snails from these rocks were described by him in this Journal, in 1872. During the summer of that year he was assistant geologist in the geological survey of the Territories under Dr. F. V. Hayden, and among his important results, as set forth in his excellent report, there is the identification by fossils of the Quebec group in Idaho, and also at the base of the Archæan Teton range. During the years 1869 to 1875, Mr. Bradley was Professor of Geology and Mineralogy in the University of Tennessee; and while there he made a detailed section of the unaltered Lower Silurian formations and the continuation of the beds in crystalline rocks on the east; and the results of his careful work are embodied in a communication to this Journal in 1876 "on the Silurian age of the Southern Appalachians." During the same year he prepared, and in 1876 published, a valuable, though small, geological map of the United States.

Professor Bradley left his position at Knoxville in 1875, with the hope of so adding to his resources, that he might be able to pursue his favorite science untrammeled by outside obligations; and it was in laboring toward this end, but before his expectations had been realized, that he met with his untimely death.

Professor Bradley was a man of profound zeal for science, of exactness in observation, of great energy, and of independent judgment and purpose. His tall, straight figure, neatly dressed, but after a fashion dictated by his work and not by prevalent modes, exhibited his independence of character no less than his strongly drawn physiognomy. His lines of action were laid down by his sense of what was right and just, and once fixed, even if bearing only on the position of a comma in a proof sheet, there was no swerving. He even contemned any accommodation to circumstances in order to avoid friction, and met with more of this than he need have encountered. But he was a man of real kindness of heart, of warm friendships, and of great uprightness.

Professor Bradley was married to Miss Sarah M. Bolles of New Haven, in 1867. He leaves a wife and one young daughter, an infant child having died on the day of his own death. J. D. D.

DOVE, the eminent professor of Physical Geography at Berlin, died on the 6th of April, at the age of seventy-seven.

W. K. CLIFFORD, of University College, London, an able mathematician, died at Madeira, early in March.

structure, which is, however, probably the same as that of the Itaparica reef.

In my former description of the Itaparica reef I stated that, while the lower portion was plainly made up in large part of true corals, the upper part appeared to contain only nullipores. I have since found that the worm tubes covering the surface of the reef enter very largely into its structure, probably to as great an extent as the nullipores, and give rise to an exceedingly hard, calcareous rock from which, ultimately, all traces of the worm-tube structure disappear. The worm-tubes and nullipores evidently compose the entire upper half of the reef. The nullipores, in the upper portions, so far as my observations went, were all of the encrusting lichen kind, and resulted in a compact structure, showing a sort of wavy lamination which is due to the successive growths of nullipores. The large digitate nullipores, so common at Pernambuco and at many places in the Bay of Bahia, are limited to the lower part of the reef, where they are associated with the true corals. At present nullipores are living in abundance only on the outer side of the reef, to a height of about one foot above medium low tide. Above the line of nullipores we find the entire upper surface of the reef coated with a layer of living worm tubes and large barnacles. The latter are generally broken off by the waves when dead, but the former remain, producing a loose structure near the surface, which becomes more compact below. The existence of nullipores in this upper portion indicates, however, that they lived on top of the reef at no distant time, and probably also that the reef has been elevated to a slight extent since then.

Within the reef the water is very shallow, being deepest near the reef and especially at and around the openings through it; it gradually shallows inward toward the beach. The bottom of this shallow inner channel is covered with sand and fragments of all sizes of corals and shells. Corals were not found in an upright position in this channel, nor do living corals exist there at all. The coral fragments are all old, frequently much worn, and almost invariably covered with nullipore and bryozoan growths, also dead. They form beds of considerable thickness in places, often more or less consolidated, and are dug up to burn for lime. The species discovered among the fragments are all found living in various parts of the bay, excepting *Mussa Harttii*, which does not apparently live at present anywhere in the Bay of Bahia. This extensive accumulation of broken corals, which must have been formed by the breaking off and heaping up of living corals from the surface of the reef by the breakers, when the reef was at a lower level, testifies to the exceeding richness of the coral life at that time. Corals have apparently ceased to be reef-builders in the Bay of Bahia.

3. *Semi-metamorphic fossiliferous rocks containing Serpentine.*—Dr. J. W. Dawson mentions facts on this subject from which the following are cited.

On the Saguenay River, at Lake Chebogamong, there is a band of serpentine associated with limestone; and Mr. Richardson obtained there a fossil tabulate coral which has part of its cells filled with serpentine, and also veins of serpentine intersecting it. The species is *Astrocerium pyriforme*, a species very common in the Upper Silurian limestones of the region in which it occurs, and characteristic especially of the Niagara formation. The formation containing the serpentine and limestone "is described as consisting of chloritic slates, in some places with hornblende crystals, dolomites, and hard jaspery argillaceous rocks."

At Melbourne, in the province of Quebec, rocks, referred by Logan to the Quebec group, pass upward into a thick series of hydromica schists, associated with quartzose bands and lenticular layers of crinoidal limestone. Over these, according to Logan, lies serpentine in thick beds (undoubtedly bedded rocks and not "eruptive") with other hydromica schists, limestone breccia, arenaceous beds, beds of anorthite, steatite, dolomite and red slates. The serpentine in the line of strike passes into dolomite and red slate. Fossils occur in the limestone interstratified with the serpentine, and also disseminated serpentine. The fossils are "*crinoidal* joints, fragments apparently of *Stenopora*," and tubular bodies which may be portions of *Hyolithes* or *Theca*, having an interior of calcite and a coating of serpentine. The cells of the fossils are sometimes filled with the serpentine; and the crinoidal joints are surrounded by it, with dolomite within.

Slices of these specimens, and those of other localities, were made by Mr. Weston when under the direction of the late Sir W. E. Logan. The other localities include Stamford, Farnham, Cleveland, Bedford, Oxford, Athabaska, Point Levi, Rivière du Loup, in most of which Lower Silurian fossils occur associated with hydrous silicates.

A locality at Pole Hill, in New Brunswick, discovered by Mr. C. Robb, has afforded specimens consisting of "fragments of crinoids and shells finely injected with an olive-green hydrous silicate of alumina, iron and magnesia. In one shell, apparently an *Orthoceras* or *Theca*, the dark green filling has cracked in the manner of Septaria [as often true of crinoidal stems in the Subcarboniferous of the Mississippi valley] and the fissures have been filled with carbonate of lime.

4. *The Physical History of the Triassic Formation of New Jersey and the Connecticut Valley*; by I. C. Russell (Ann. N. Y. Acad. Sci., i, 220–254).—The author, after giving some account of the Triassic formation of New Jersey and the Connecticut Valley, discusses the origin of the westward dip of the former and eastward of the latter. He adopts the hypothesis, suggested by Professor Kerr for the Trias of North Carolina, and by Professor F. H. Bradley for the regions of which Mr. Russell treats, that the New Jersey and Connecticut beds are opposite parts of an anticlinal. He holds also that the sandstone was once continuous over the whole intermediate region. The view is sustained on the ground

that the dip of the sandstone is in opposite directions in the two areas—10° to 15° northwestward in New Jersey, 5° to 50° [averaging 15°] to the eastward and southeastward in the Connecticut Valley; and on the view of a conglomerate on the western border of the former and eastern of the latter, whence it is inferred that here were the coast lines of the great estuary. Calculations from the dip give him for the thickness of the sandstone 25,000 feet, the consideration of faults in the beds being rejected by the author as without "plausible" support.

The hypothesis has objections, some of which, as they appear to the writer, are here stated.

(1) A thickness of 25,000 feet of water-made sandstone over an area of metamorphic rocks more than 100 miles in width, large portions of which are now several hundred feet above the sea-level, implies a subsidence of this region of over 25,000 feet, during the formation of the sandstone, or else, this depth of water.

(2) It implies also an elevation of the whole region—100 miles wide between the eastern and western limits—not only to this amount, 25,000 feet, but enough higher to give the average pitch of 15° eastward in the eastern sandstone and 10° to 15° in the western. For a width in the Connecticut Valley of fifteen miles (the area averages twenty), the dip produced by the alleged uplifting if only 14°—supposing no faults—would put the *western side of the Connecticut Valley* 20,000 *feet above its eastern;* and the site of New York City, on the eastern 15,000 or 20,000 feet above its present level, with 25,000 feet of sandstone over it. How much higher such an elevation would place the central portion of the region between the Connecticut Valley and New Jersey, the reader can calculate. Mountains on the globe at the present day are small in comparison.

(3) The hypothesis asks for an incredible amount of denudation; crystalline rocks of great depth as well as sandstone, over an area more than fifty miles wide having to be removed, and the surface brought down to its present level.

(4) The southern limit of the Connecticut Valley sandstone area is *north of the northern* limit of the New Jersey. The New Jersey area cannot, therefore, be on the opposite margin of the sandstone region to that of the Connecticut Valley. That there should have been an opposite side to the Connecticut Valley anticlinal, the New Jersey Trias should have extended up the Hudson River to Albany, N. Y., 120 miles north of its most northern point, Albany being in the same latitude with its northern limit in the Connecticut Valley; and hence the whole of western Massachusetts as well as of Connecticut, and all of Eastern New York, south of Albany, including the Green Mountain region, must have been raised to the enormous altitude referred to; and, besides, the sandstone must have since been removed from the whole so that no trace was left, with the exception of the Southbury basin. Further, the opposite side of the New Jersey part of the arch must have been somewhere out in the Atlantic south of

Long Island; and this island must have participated in the upward bend.

It is however to be admitted that, with the suggested method of accounting for the dip in the Connecticut Valley sandstone, there was no need of any sandstone in the Hudson River Valley; and, no need, in fact, of any sandstone over the intermediate region of crystalline rocks between that valley and the New Jersey area.

(5) No evidence of such an anticlinal, or of the supposed amount of erosion, exists excepting this—that the sandstone of the Connecticut Valley dips eastward, and that of New Jersey, situated wholly to the south of the southern limit of the Connecticut Valley area, dips northwestward, at the angles stated.

The existence of a conglomerate along the eastern border of the Connecticut area can be accounted for on the usual view—that this area in Triassico-Jurassic times was a Connecticut Valley estuary, at the termination of the Connecticut River, and had its violent floods, which may have been for part of the time enlarged by the waters and ice of a semi-glacial era—quite as well as by that of its being the eastern part of a much larger estuary; and even better.

The features of the Connecticut Valley beds afford other arguments; but it is not necessary to bring them up at this time.

J. D. D.

5. *Geological Survey of Pennsylvania.*—The following volumes containing Reports of Progress of this survey, have been recently issued, in addition to that by Mr. C. A. Ashburner mentioned on a former page of this volume. They show great activity in the Survey.

I. *Report of Progress of Bradford and Tioga Counties* (G), 272 pp. 8vo, with maps and sections; including: 1. on the Limits of the Catskill and Chemung formations, by A. Sherwood; 2. Descriptions of Coal fields, by F. Platt; and 3, on the Coking of Bituminous Coal, by J. Fulton.

II. *Report of Progress in Indiana County* (HHH), by W. G. Platt, 316 pp. 8vo, with a colored map of the County. 1878.

III. *Catalogue of the Geological Museum*, Part I, Rock specimens. 218 pp. 8vo. 1878.

IV. *The Brown Hematite Deposits of the Siluro-Cambrian limestones of Lehigh County, lying between Shimersville, Millerstown, Schnecksville, Ballietsville, and the Lehigh River* (DD), by Frederick Prime, Jr.; 100 pp. 8vo, with 5 map-sheets and 5 plates. 1878.—Professor Prime, shows that the rocks of the region, above the Laurentian, are, in succession, (1) the Potsdam sandstone; (2) a Siluro-Cambrian magnesian limestone, which has afforded Chazy fossils, besides an Orthoceras and Lingulæ too imperfect for determination; (3) Damourite (Hydromica) slates, all in general conformable; also (4) the Trenton limestone, as a direct continuation of the magnesian limestone, the beds affording encrinital stems identical with those found in Northampton

County overlying characteristic Trenton fossils; and (5) Hudson River slates, also conformably continuous with the preceding. Professor Prime treats also of the origin of limonite beds associated with the damourite slates, and of other points in the geology of the region. His method of determining the age of the crystalline schists by means of the fossils in the conformably associated strata gives positive results.

V. *Special Report on the Trap-Dykes and Azoic Rocks of Southeastern Pennsylvania* (E), by T. STERRY HUNT. Part I. Historical Introduction. 254 pp. 8vo. 1878.—This Historical Introduction is a general exposition and re-statement of the author's views on the "Azoic," Cambrian and Silurian rocks, of this and other countries, and the application of lithology to classifying and fixing the age of the various crystalline rocks, besides notes on eruptive rocks, along with a historical account of former views on these and other subjects, and a statement of the observations from various sources that appear to favor the views set forth. It is valuable as a definite exhibition of the present state of such views in the science, and of the arguments—not always just to the observations of others—by which they are sustained. The progress of the science will show how much of truth there is in them.

J. D. D.

6. *Report of the Geological Survey of Ohio.* Vol. III, *Geology and Palæontology.* Part I, *Geology.* 954 pp. 8vo.—This large volume consists, after its Preface by Professor J. S. NEWBERRY, the head of the Survey, of a Review of the Geological Structure of Ohio by Professor Newberry, and chapters on the Geology of different counties by the same, and the Assistant Geologists, Messrs. J. J. STEVENSON, M. C. READ, A. W. WHEAT, EDWARD ORTON, JOHN HUSSEY, F. C. HILL, A. C. LINDEMUTH, J. T. HODGE and H. HERZER, with supplemental Reports by E. B. ANDREWS and E. ORTON.

From Professor Newberry's Review we take the following conclusions.

The Cincinnati group does *not* represent the Hudson River group of New York, but the whole Trenton series, including the Trenton limestone and Hudson River group.

Many fossils of the Oriskany sandstone in Canada West, as *Spirifera arenosa*, *S. arrecta*, *Rensellaeria ovoides*, and *Avicula arenosa* are found mingled with *Favosites Gothlandica*, *Zaphrentis prolifica*, *Conocardium trigonale*, *Platyceras nodosum*, and many other well known fossils of the Corniferous limestone, which facts, in addition to the entire absence of Upper Silurian species, prove the Oriskany to be much more closely allied to the Devonian than to the Silurian.

The "Black shale" or "Huron shale" of the Devonian is made up of the black shales of the Lower Portage and the Genesee. In the shale, besides the gigantic *Dinichthys*, the jaw of a large Placoderm has been obtained which has been referred to a new genus, *Diplognathus*, also a new species of *Dinichthys*, a new *Ctenacanthus*, and several of *Cladodus*.

The volume contains much of great value to the science that would be here cited but for the limited space.

7. *Journal of a Tour in Marocco and the Great Atlas;* by Sir JOSEPH DALTON HOOKER, President R.S., etc., and JOHN BALL, F.R.S.;—*with an Appendix including a sketch of the Geology of Marocco;* by GEORGE MAW, F.G.S., etc. 499 pp. 8vo. London: 1878. (Macmillan & Co.).—This volume contains an account of a journey made by Sir Joseph Hooker, Mr. Ball and Mr. Maw in 1871 to a region which, as the preface remarks, was then little better known to geographers than it was in the time of Strabo and Pliny. The general account of the journey, occupying the first 348 pages, contains, besides incidents by the way, much information on the features, vegetation, and people of the country. It is followed by Appendixes on the Geography of the region, by John Ball; on its economic plants, a comparison between the Flora of the Canary Islands and of Marocco, and between that of Tropical Africa and of Marocco, by J. D. Hooker; on the Mountain Flora of two valleys of the Great Atlas, by J. Ball; on the Geology of the plain of Marocco and the Great Atlas, by George Maw.

The geological chapter contains much on the glacier phenomena of the Atlas region. "Unquestionable moraines" were observed in the province of Reraya, at a height of 6,000 feet, where was a "gigantic ridge of porphyry blocks," "with no admixture of small fragments," 800 to 900 feet in vertical height, damming up the deep ravine. The beds of bowlders flanking the northern escarpment of the Atlas plateau spread downward in great mounds and undulating ridges from a height of 3,900 feet to the borders of the plain 1,900 feet above the sea; and the moraines, commencing at a height of 5,800 feet, stretch up the Atlas ridge to a height of between 7,000 and 8,000 feet. Behind the moraines, at 6,200 feet, there was observed a plain of shingle, which seemed to be the bed of a small lake. At present there is not even perpetual snow on any part of the Atlas range. Since the era of the glaciers, the coast line has been raised at least seventy feet, as indicated by raised beaches at Mogador "which may possibly be cotemporaneous with raised beaches on the coasts of Spain and Portugal." A slight subsidence of the coast-line is stated to be now going on.

8. *Annual Report of the State Geologist of New Jersey, for* 1878. 132 pp. 8vo.—The prominent feature of this Report is a chapter on the "Glacial and Modified Drift" of the State, which is illustrated by a large map, showing the surface covered by the drift, the course of the "terminal moraine," and the "Oak Lands" and "Pine Lands." It treats also of the soils of the State, clays and their compositions, clay deposits, glass sand, progress of the topographical survey of the State, and gives analyses of some iron ores and limestones.

9. *Geological Record for* 1876; *an account of works on Geology, Mineralogy, and Palæontology, published during the year; with supplements for* 1874 *and* 1875. Edited by WM. WHITAKER, B.A., F.G.S., of the Geological Survey of England.

415 pp. 8vo. London, 1878. (Taylor & Francis.)—The third volume of the Geological Record is fully up to its predecessors in scope and thoroughness. The value of the work, to all engaged in the sciences included, would seem to be so obvious that it is a matter of surprise and regret that the editor should be compelled to call for more subscribers to insure its continued success.

10. *The Study of Rocks; An Elementary text-book of Petrology;* by Frank Rutley, F.G.S., of the Geological Survey. 319 pp. 12mo. London: 1879. (Longmans, Green & Co.).—The study of rocks by the microscope is now recognized as so important a part of lithology and so universally employed, that an English text-book giving the methods employed cannot fail to be appreciated. The work is about equally divided between the description of methods of making thin sections and of examining them in the microscope, the description of the rock-making minerals, and of the rocks themselves. Mr. Rutley's work is a convenient one for the student. It is not, however, free from errors; the description and figure on page 94 show that the mineral referred to must be *microcline* and not orthoclase.

11. *Ueber die Zusammensetzung der Lithionglimmer*, von C. F. Rammelsberg.—Professor Rammelsberg has made a new examination of the lithia mica, lepidolite, with special reference to the amount of alkalies present. He finds that many of the previous analyses are incorrect in the determination of the lithia, and in this respect he rejects the analyses of Berwerth upon which Tschermak based his recent conclusions as to the chemical formula (this Journal, III, xvii, 176). For the lepidolite of Paris, Me., and Rozena, Rammelsberg writes the formula $\overset{\text{I}}{R}_2AlSi_3O_{10}$.—(*Ber. Ak. Berlin*, Oct. 28, 1878.) E. S. D.

12. *On the composition of Spodumene and Petalite;* by C. Doelter.—Dr. Doelter has recently analyzed spodumene from Norwich, Mass., (1) and from Brazil (2) with the following results:—

	SiO_2	AlO_3	FeO	CaO	MgO	Li_2O	Na_2O	K_2O	
(1)	63·79	27·03	0·39	0·73	0·21	7·04	1·10	0·12	=100·41
(2)	63.34	27·66	1·15	0·69	...	7·09	0·98	..	=100·91

After making allowance for impurities, he obtains for the quantivalent ratio of $\overset{\text{I}}{R}:Al:Si=1:3:8$ (instead of 1 : 4 : 10 previously accepted) and writes the formula $\overset{\text{I}}{R}_2AlSi_4O_{12}$, where $\overset{\text{I}}{R}=Li$ and Na in the ratio of 15 : 1.

The composition of petalite is also discussed and the conclusion reached that is expressed by the formula $\overset{\text{I}}{R}_2AlSi_{10}O_{24}$, and the opinion is advanced that petalite bears the same relation in composition to spodumene that albite does to anorthite. E. S. D.

13. *Cacoxenite from Lake Superior.* (Communicated).—Mr. E. Claassen of Cleveland has identified cacoxenite on the martite of Lake Superior. It appears in brownish-yellow acicular crystals forming radiating tufts.

14. *A titaniferous Chrysolite.*—M. DAMOUR has described a titaniferous chrysolite from Zermatt, Switzerland. It has a red color, similar to that of almandine garnet; G.=3·27. An analysis afforded SiO_2 36·14, TiO_2 6·10, MgO 48·31, FeO 6·89, MnO 0·19, ign. 2·23=99·86; this gives almost exactly the required ratio of 1 : 1 for bases to silicon.—(*Bull. Soc. Min. France*, ii, 15.)

15. *On the crystalline system of Pyrostilpnite* (*Fireblende*).—STRENG, in a paper devoted to a thorough crystallographic description of some silver minerals from Chañarcillo, Chili, states that pyrostilpnite (feuerblende) belongs to the orthorhombic, not the monoclinic, system. The conclusion is based both upon the measured angles and the optical character.—(*Jahrb. Min.*, 1878, 897).

16. *Die Meteoritensammlung der Universität Göttingen*, von C. KLEIN.—The collection of meteorites at Göttingen, according to the recent catalogue of Professor Klein, is one of the great collections of the world, including meteoric stones from 115 distinct falls, and 90 meteoric irons from different localities.

17. *Enstatite rock from South Africa.*—Professor Maskelyne has described a rock from two localities in the Transvaal, South Africa, consisting solely of massive enstatite. This is a kind previously not recognized in lithology, although rocks have been known which, as lherzolyte, contain enstatite as a prominent ingredient.

III. BOTANY AND ZOOLOGY.

1. *Polyembryony, true and false, and its relation to Parthenogenesis.*—Strasburger has an interesting paper, *Ueber Polyembryonie*, in the Zeitschrift für Naturwissenschaft of Jena (1878), which we know as yet only at second hand, chiefly from a notice in the Archives des Sciences Phys. et Nat. of February, 1879.

Strasburger's researches upon the fecundation of the angiospermous Phænogams show that the embryo-sac very seldom produces more than one embryonal vesicle which is fecundated or capable of being fecundated. The single constant exception to this rule, known to him, is that of *Santalum album* which produces two; and one or two Orchids are mentioned in which the embryonal vesicle divides into two, occasionally. True polyembryony must therefore be very rare in Angiosperms. But seeds containing more than one embryo are of common occurrence in oranges, in *Funkia*, *Allium* or *Nothoscordum*, etc. According to Strasburger, all supernumerary embryos in such cases are adventitious, originate outside of the embryo-sac by a kind of prolification in the nucleus, and are not fecundated at all. They appear in the form of minute cellular protuberances, which lengthen by degrees and push into the embryo-sac by a sort of hernia, or pierce their way into it, becoming in the ripe seed veritable embryos, which it is not easy to distinguish from the one resulting from the fecundation of the embryonal vesicle itself. Independent as these adventive embryos are of fecundation, yet Strasburger could not obtain them in *Nothoscordum* when he had extirpated the stamens before an-

thesis and prevented access of pollen. But it appears that *Cœlobogyne* is just a case of this kind, namely, one in which an adventive embryo is habitually produced, instead of the normal embryo which fails from the want of fecundation, the male plant not being in cultivation. It is understood that this is not a mere inference, but that Strasburger has traced the development of the embryonal vesicle in the ovule of *Cœlobogyne*, followed by its failure and resorption, and by the independent production of adventive embryos in the manner above described.

This, then, gives an explanation of the long-disputed *parthenogenesis* of *Cœlobogyne*, and therefore of the less notable instances. Parthenogenesis, it is then concluded, is only in appearance; it is sometimes, and perhaps in all cases, "a prolification of the nucleus." Now we should insist that, since the result is "a veritable embryo" (equivalent in structure, position of radicle, and ultimate growth to the true embryo), and not a bud, parthenogenesis is the just name; that the very interesting and important conclusion attained is that parthenogeny results, not from the development of an unfecundated embryonal vesicle, as was supposed, but from a development of other and extraneous cells into an embryo; also that it is not very rare, since the adventive or supernumerary embryos of various seeds are cases of this par thenogeny.

Not the least interesting consideration is, that we have here a counterpart of what De Bary terms *Apogamy*,—instead of an analogue of it. *Apogamy* is a vegetative prolification from what should normally result in the product of sexual reproduction. *Parthenogeny* proves to be the inverse of this, a vegetative production in the ovule of the proper result of sexual reproduction, viz: embryo. And finally, we have in these two modes taken together—what was quite to be expected—a manifest and significant narrowing of the *hiatus* between vegetative and sexual reproduction, which Mr. Darwin may turn to account.

Some applications of this new knowledge may be made. It is quite possible that more embryos than we are aware of may be adventive. Rather more than a year ago we gave an abstract in this Journal* of Mr. Francis Parkman's interesting paper on the hybridization of Lilies. It may be remembered that the greater part of his hybrids exactly reproduced the female parent. The explanation which we suggested to him, and which he refers to in his paper, was, that those plants were not really hybrids at all, but were from embryos originated without male influence. What then seemed to us the least improbable explanation, would now appear to be the one altogether probable. A. G.

2. *Notes on Euphorbiaceæ.* By George Bentham. (Extr. Jour. Linn. Society, No. 100, Dec., 1878, vol. xvii. pp. 185–267).—This thoughtful essay presents the general views attained to by Mr. Bentham on working up the genera of the great order *Euphorbiaceæ* for the ensuing volume of the Genera Plantarum. We need

* The number for February, 1878, p. 151.

not specify any of the results, except to indicate the author's decision in the case of the *Buxeæ.* He does not follow his predecessors, Baillon and J. Mueller, who, much as they differ in other respects, agreed in setting up the order *Buxaceæ*, taking their cue from Agardh, and making much of the dorsal rhaphe. Bentham concludes that this small group, however well defined, ought not in a general view to be regarded as of higher grade than one of the primary divisions, or tribes, of *Euphorbiaceæ.* We are not the less pleased with this that we quite expected it.

A wider interest will be felt in Mr. Bentham's *excursus* on nomenclature, or rather on some questions which the study of *Euphorbiaceæ* brought up, and which some recent discussions have made pertinent. The general laws of nomenclature of our day, and the principles on which they rest, are laid down in the code which was reported by Alphonse DeCandolle to the Paris International Convention, in the year 1867, and, being approved, was published with a commentary in the autumn of that year, and in an English translation early in the following year. The laws, without the commentary, were printed in this Journal for July, 1868. The ten years succeeding have tested, somewhat thoroughly, the questions (nearly all of minor moment) upon which differing usages prevailed; and though one or two points are still mooted, the great majority of phænogamous botanists are coming to be of one mind and practice. But, as Mr. Bentham remarks: "The result has not been quite effectual in checking the ever-increasing spread of confusion in synonymy. Besides the young liberal-minded botanists who scorn to submit to any rule but their own, there are others who differ materially in their interpretation of some of the laws, or who do not perceive that in following too strictly their letter instead of their spirit, they are only adding needlessly to the general disorder. In the application as well as in the interpretation of these rules they do not sufficiently bear in mind two general principles; first, that the object of the Linnæan nomenclature is the ready identification of species, genera, or other groups for study or reference, not the glorification of botanists; and secondly, that changing an established name is very different from giving a new name to a new plant."

It is to the latter point that this most experienced and even-minded botanist addresses himself. "The rule that long-established custom amounts to prescription, and may justify the maintenance of names which form exceptions to those laws which should be strictly adhered to in naming new plants, is unfortunately now frequently ignored. . . . . The law of priority is an excellent one; and when a genus or species has been well defined by an early botanist in a generally accessible work, but has subsequently been neglected, and the plant became known under other names, it is well that the original one should be restored. . . . . On the other hand, it creates nothing but confusion to suppress a generic name, well-characterized and universally adopted by long custom, in favor of a long-forgotten one, vaguely

designated in an obscure work, out of the reach of the great majority of botanists. . . . . The greater number of Necker's genera have been so imperfectly characterized, with so absurd a terminology, that they are quite indeterminable; and his names deserve to be absolutely ignored, except in the very few cases where Jussieu or other early French botanists have succeeded in identifying them, and corrected their characters; but even then it is doubtful whether these names should not bear the date of the correction, rather than of the original work. Adanson's "Familles," with all the inconveniences of its form and absurd orthography, is much more scientific, and many of his genera are well defined, and have therefore been properly adopted." . . . .

Let us here interject a practical application. There is an old and well-established genus *Smilacina* of Desfontaines. There is a much older genus *Tovaria* of Ruiz and Pavon, founded in 1794, ever since accepted, and without a synonym. Recently Mr. Baker of Kew, finding that Necker has a *Tovaria*, published in 1790, and therefore four years earlier than that of Ruiz and Pavon, takes up this name in place of *Smilacina*, and leaves a new name to be made for the long-established homonymous genus. It will be said that the rule of priority demands the sacrifice, and that the identification of Necker's genus is sure, because the three Linnæan species of *Convallaria* which properly constitute Desfontaines' *Smilacina* are referred to it by name; and that, though it be a case of *summum jus summa injuria*, the injurious consequence is a necessity. But Mr. Bentham's characterization of Necker's work applies even to this instance. Twice over Necker's *Tovaria* is described as having a perianth of five sepals, and the berry is said to be one-celled. Desfontaines' *Smilacina*, on the other hand, is correctly characterized. Moreover, if we do not include this among those names of Necker which, Mr. Bentham says, "deserve to be absolutely ignored," we may yet find that the law of priority has another claim on it. In 1763 a much better botanist than Necker, viz: Adanson, founded a genus *Tovara* (essentially the same name as *Tovaria*) on *Polygonum Virginianum* L., which is not unlikely to be taken up as a genus; and the name would supersede Necker's by the same rule that Necker's supersedes Desfontaines' *Smilacina*. All things considered, then, this is a case for the application of the homely but useful rule *Quieta non movere*; and much of Mr. Bentham's pertinent advice may be condensed into this maxim. But there remain nice questions to settle with regard to the names and extent of the liliaceous genus.

"The representing the Greek aspirate by an *h* was generally neglected by early botanists; but now, ever since DeCandolle altered *Elichrysum* into *Helichrysum*, modern purists have insisted upon inserting the *h* in all cases; and this has been so far acquiesced in that it is difficult now to object to it, though it has the effect of removing so many generic names to a distant part of all indexes, alphabetical catalogues, etc. Admitting the propriety of adding the aspirate in new names, I had long declined

to alter old names on this account; now, however, I find myself compelled to follow the current." Which is, on the whole, regrettable, especially as Alph. DeCandolle would hold out with him. See the latter's comment on his Article 66, in which the remark is dropped that, "we do not see why we should be more rigorous than the Greeks themselves." Oddly enough, these same writers who must supply the aspirate to the *e* omit it from the *r*, and write *rachis* and *raphe*, instead of *rhachis* and *rhaphe*,—which is exasperating to lovers of uniformity.

It is unnecessary here to cite Mr. Bentham's appropriate illustration of the indivisibility of the two-worded name of a plant. The proper apprehension of this, and of the paramount rule that no *unnecessary* new names should be given to old plants, will go far to rid the science of a principal remaining ambiguity in nomenclature. For it clearly follows that when a plant has a rightful name under its proper genus, the specific half of it is not to be changed because of any earlier specific name under some other genus, to which the plant does not belong. A. G.

3. *Journal of a Tour in Marocco and the Great Atlas.* By JOSEPH DALTON HOOKER, K.C.S.I., etc., and JOHN BALL, F.R.S., etc. A brief notice of the geological appendix in this work is given on page 332. We add here a few words on the botanical results. Sir Joseph Hooker contributes an article on some of the economic plants; the most important portion of which relates to the Argan tree, the natural and economical history of which is now pretty well known. The narrative contains a wood-cut figure of a group of old Argan trees, in which goats are seen high up among the spreading branches, feeding upon the fruit. Of higher scientific interest is the comparison of the Canarian flora with the Maroccan (of which we cannot here undertake an abstract); also the comparison of the Atlas flora with that of the mountains of Grenada, and of northern Europe. So far as is yet known, the north European or Germanic character largely preponderates in it, yet absolutely without alpine representatives. These last probably exist, but at elevations which have not yet been reached. It was a trying experience to have surmounted a pass of the Great Atlas range, only to encounter a snow-storm, and to be obliged to turn back without reaching the higher crests so near at hand. Mr. Ball has worked up the botanical results technically and systematically in his *Spicilegium Floræ Maroccanæ*, which fills nearly 500 pages of the sixteenth volume of the Journal of the Linnean Society, and is illustrated by twenty plates. A. G.

4. *Eaton's Ferns of North America.*—We are not sure that we have noticed the later issues of this work, so important to all fern-people and botanists. But, in any case, we must make a note of Parts 12 and 13, a double number, which has just come to hand, the plates are so excellent. As to the letter-press, this is always satisfactory. *Aspidium acrostichoides* is well represented, and well colored. The same would be said of *Pteris aquilina*, were it not that the frond looks diminutive. The three *Asplenia* make a

fine plate. But the figure of *A. parvulum* is stiff: we never saw it growing bolt upright, and the difference in size between this and the other two is not made sufficiently manifest. A somewhat more northern range must be assigned to this species. We found it rather common in the mountains of the southern part of Virginia, as well as in North Carolina. *Adiantum Capillus-Veneris*, the subject of the next plate, and which is luxuriantly delineated, has just now come in from the same region in Virginia,—a discovery by Mr. Shriver. *A. emarginatum* would have been perfectly presented if the green were brighter and lucid. The three species of *Notholœna* make an admirable plate. A. G.

5. *Algæ Amer. Bor. Exsiccatæ;* by FARLOW, ANDERSON & EATON, *Fasc.* III.—The third Fasciculus of this distribution of North American Algæ has just been issued. It consists of only thirty specimens, covering twenty-nine species and one variety. But as most of the species are large plants, the paper used is of the folio size of most American herbariums. Twenty of the Algæ are of the black or olive-green series, and the other nine are Florideæ. Among the rarer kinds are *Sargassum pterpleuron*, from Florida, *Postelsia palmæformis*, *Pterygophora Californica*, *Dictyoneuron* and *Nereocystis*, from the Pacific Coast, and *Saccorhiza dermatodea*, from the coast of Maine. The Florideæ embrace several of the large *Gigartinas* of the Pacific shore, and three or four of those very puzzling forms of *Callophyllis*, which have so long been an unsolved riddle to the students of this class of plants. Dr. Farlow, who has done nearly all the work of identification, still hesitates to acknowledge the presence of the European *Callophyllis laciniata* on the coast of California; but then he has named two new species of the genus, No. 127, *C. furcata*, and No. 129, *C. gracilarioides*.

This is a very important publication, on account of the care, labor, expense, and critical investigation which are bestowed upon it, not to speak of the beauty and perfection of the specimens; and the associated authors should receive the best thanks of botanists. A. G.

6. *On the Black Mildew of Walls.*—Professor LEIDY remarked that in the number of "Hardwicke's Science Gossip" for August, presented this evening, there is an article by Professor Paley entitled, "Is the Blackness on St. Paul's merely the effect of Smoke?" According to the author, the blackness is mainly due to the growth of a hitherto undescribed lichen, which appears to flourish on limestone and in situations unaffected by the direct rays of the sun. Professor Leidy continued, that his attention had been called a number of years ago to a similar black appearance on the brick walls and granite work of houses in narrow shaded streets, especially in the vicinity of the Delaware River. Noticing a similar blackness on the bricks above the windows of a brewery, from which there was a constant escape of watery vapor, in a more central portion of the city, he was led to suspect that it was of a vegetable nature. On examination, the black

mildew proved to be an alga, closely allied to what he supposed to be the *Protococcus viridis*, which gives the bright green color to the trunks of trees, fences, and walls, mostly on the more shaded and northern side, everywhere in our vicinity. It probably may be the same plant in a different state, but, until proved to be so, may be distinguished by the name of *Protococcus lugubris*. It consists of minute round or oval cells, from 0·006 to 0·009^{mm} in diameter, isolated or in pairs or in groups of four, the result of division; or it occurs in short irregular chains of four or more cells up to a dozen, occasionally with a lateral offset of two or more cells. The cells by transmitted light appear of a brownish or olive-brownish hue. In mass to the naked eye the alga appears as an intensely black powder.—*Proc. Acad. Nat. Sci. Philad.*, Sept. 3, 1878.

7. *On two Bermuda fishes, mistakenly described as new;* by Dr. A. Günther.—In the February number of the Annals and Magazine of Natural History, pp. 150–151, is published a paper by Dr. A. Günther, F.R.S., "On two new Species of Fishes from the Bermudas." The species which he names *Gerres Jonesii*, was described by me in this Journal, vol. vii, August, 1874, p. 123, under the name *Diapterus Lefroyi;* that called by him *Belone Jonesii*, was also described by me, under the same name, and dedicated to the same worthy naturalist, in this Journal, vol. xiv, October, 1877, p. 295. The descriptions harmonize in all essential details, and I have myself seen the specimens which were subsequently presented by Mr. Jones to the British Museum, though my own descriptions were drawn up from other specimens collected by myself at nearly the same time and locality.

Smithsonian Institution, Feb. 17, 1879. G. BROWNE GOODE.

8. *Alaska Chitons and Limpets.*—A paper on this subject, by W. H. Dall, giving a synopsis of the genera and notes on the various species with their synonymy, makes a number of the Bulletin of the U. S. National Museum. It is illustrated by four plates, and some wood-cuts, representing the dentition of many of the species. The Bulletin is not yet separated into volumes, and this paper is No. 4 of Mr. Dall's "Scientific Results of the Exploration of Alaska," the first two numbers being in Proc. Philad. Acad., 1876.

IV. Miscellaneous Scientific Intelligence.

1. *On the discovery of mineral wax, Ozocerite, in Utah;* by Professor J. S. Newberry. (From a letter to the Editors.)—I have obtained some of the recently discovered ozocerite in Salt Lake City from Professor J. E. Clayton, to whom also I am chiefly indebted for such information as I have in regard to its place and manner of occurrence. He writes me as follows: "The geographical position of the ozocerite deposits is in the Wahsatch Range, on the head waters of the Spanish Fork, east from the south end of Utah Lake. The material has been found saturating

beds of brown and bluish shales, probably of Tertiary age, and in masses of various dimensions more or less mingled with clay. These shales extend from the San Pete valley in a north-northeast direction for a distance of fifty or sixty miles, and the width of the area or basin which they occupy is at the middle point about twenty miles. The shale beds richest in paraffine vary in thickness from twenty to sixty feet, but there is no considerable accumulation of that substance on the surface, nor would this be possible, as it would be destroyed by the annual fires which sweep the country. I examined portions of this region two years ago for coal, and found in the oil shales a few thin seams, and saw the wax-like exudation in several places, but only in small quantity."

Other parties in Salt Lake informed me that the paraffine itself is sometimes twenty feet thick, and that the quantity is enormous; but Professor Clayton says that such statements are not authorized by any facts which have come under his observation.

In the above remarks I have called the earth wax of Utah ozocerite. As it has been stated to be zietrisikite, I may say that on my return from the west, my son and assistant, Spencer B. Newberry, made a series of careful experiments in my laboratory to determine its true nature, comparing it with the description of these hydrocarbons, and with authentic specimens which I have received directly from Galicia. He found that it had a melting point of 61·5° C., that it was completely soluble in a large volume of boiling ether, and that boiling alcohol extracted from it twenty per cent of a white, wax-like substance. It seems, therefore, to be certainly ozocerite and not zietrisikite; the latter melting at 90° C., and being insoluble in ether.

2. *The American Antiquarian: A Quarterly Journal* devoted to early American History, Ethnology and Archæology, edited by Rev. STEPHEN D. PEET. Cleveland, Ohio. (Brooks, Schinkel & Co.).—The third number of this new Journal was published in January, 1879; among other papers it contains one on native American Architecture, by E. A. Barber, which is illustrated by several figures of Colorado Cliff houses. The Journal is well edited and promises to be of value to all interested in Archæology.

3. *Wanderings in South America, the Northwest of the United States and the Antilles, in the years* 1812, 1816, 1820, 1824; by CHARLES WATERTON, Esq. New edition, edited with biographical introduction and explanatory index, by the Rev. B. G. Wood. 520 pp. 8vo. London, 1879. (Macmillan & Co.).—The volume of "Waterton's Wanderings" was first published in 1825, and since that time it has afforded pleasure and profit to a large number of readers. In the present edition the original account is left unaltered, but to this are added a full and appreciative biography of the author, by the Rev. B. G. Wood, and a valuable Explanatory Index, covering 150 pages, in which information is given in regard to the many unusual animals, birds and trees, mentioned in the body of the work.

4. *A Real Telegraph.*—A new invention of a really practical character, not a mere "paulo post futurum" invention like many we have heard of lately, has just been made by Mr. E. A. Cowper, the well-known mechanical engineer. It is a real telegraphic writing machine. The writer in London moves his pen, and simultaneously at Brighton another pen is moved, as though by a phantom hand, in precisely similar curves and motions. The writer writes in London, the ink marks in Brighton. We have seen this instrument at work, and its marvels are quite as startling as those of the telephone. The pen at the receiving end has all the appearance of being guided by a spirit hand. The apparatus is shortly to be made public before the Society of Telegraph Engineers.—*Nature*, Feb. 6.

5. *The chemical composition and physical properties of Steel Rails.*—Dr. C. B. DUDLEY, Chemist of the Pennsylvania Railroad Company, has made an extended investigation of the relation between the chemical composition of steel rails and their power to withstand wear, and in view of the great practical importance of the subject his results cannot fail to have a high value. Some of his conclusions are:—that high phosphorus is inconsistent with safety; that the silicon should be as low as is consistent with the successful working of the Bessemer process; that the best range of carbon is 0·25 to 0·35 per cent, and of manganese from 0·30 to 0·40 per cent. He also concludes that the wearing power of steel rails does necessarily increase with their greater hardness.—(*Trans. Inst. Min. Engineers*, vol. vii.)

6. *The Meteorologist*, published monthly in the interest of the Science of Meteorology. Vol. i, No. 1, March, 1879, J. M. L. STUMP, editor, Greensburg, Pa. An eight-page journal devoted to meteorology.

7. *The Paleontologist.* No. 3, Jan. 15, 1879, Cincinnati. Contains description of new species of fossils from the Lower and Upper Silurian rocks of Ohio, by U. P. James.

OBITUARY.

Professor GUSTAV LEONHARD, of Heidelberg, died December 27, 1878. He was well known as the author of works on Mineralogy and Geognosy, and as editor with Professer H. B. Geinitz, of the Neues Jahrbuch für Mineralogie, Geologie und Paleontologie.

On the extent and significance of the Wisconsin Kettle Moraine, by T. C. Chamberlain, A.M., State Geologist and Professor of Geology in Beloit College (Trans. Wisc. Academy of Sciences.)

On the Annelida Chætopoda of the Virginian Coast, by H. E. Webster (Transactions of the Albany Institute, vol. ix, January, 1879.)

Apuntes relativos à los Huracanes de las Antillas en Septiembre y Octubre de 1875 y 1876; Discurso leido en la real Academia de Ciencias Medicas, Fisicas y Naturales de la Habana en Sesion del 9 de Septiembre de 1877 y siguientes; par el socio de merito Rdo, P. Benito Viñes, S. J., Director del Observatorio. 25) pp. 8vo. Havana, 1878.

The Local Geology of Davenport, Iowa; by Rev. W. H. Barris (Davenport Academy Natural Sciences, Sept., 1876). New Fossils from the Corniferous Formation at Davenport (ibid., Oct., 1878).

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[THIRD SERIES.]

ART. LIII.—*The Forests of Central Nevada, with some remarks on those of the adjacent regions;* by CHARLES S. SARGENT.

To the traveler crossing the Great Basin by the line of the Pacific Railroad the country will appear almost as destitute of trees as the great plateau over which he has passed in approaching the Rocky Mountains from the east. This first impression will disappear, however, should he penetrate farther south, and ascend some of the low mountain ranges, which, with a general north-and-south trend, everywhere cut up this elevated interior region into long, narrow valleys. As compared with our Atlantic forests, or those still nobler ones which, farther to the west, owe their existence to the influence of the Pacific, the forests which clothe, with a scanty and stunted vegetation, the mountain slopes of Nevada are miserably poor in extent, productiveness, and especially in the number of species of which they are composed. Actually they are of immense value. For scanty as they are, they regulate and protect the rare and uncertain streams on which the agriculture of Nevada depends, and furnish a large population with fuel and lumber; a population, too, which, while consuming and wasting enormously its forests in vast mining operations, is practically cut off, by its isolation and the cost of transportation, from outside supply.

A hurried journey made in Septemper last, undertaken for the purpose of studying *in situ* the trees of the "Great Basin," and of introducing into cultivation some of the peculiar plants of that region, took me to the great mining center of Eureka, and then through Dry and Fish-spring valleys seventy-five miles further southwest into the Monitor Range, to the point

where its highest peak, "Table Mountain," reaches an elevation of 11,200 feet, and offered an excellent opportunity to examine the timber supply of that central portion of Nevada.

The forests of this portion of the State are composed of but seven species. Of these, two, the Red Cedar (*Juniperus Virginiana* L.) and the Aspen (*Populus tremuloides* Michx.) extend across the Continent; two, *Pinus Balfouriana* Murr. and *Pinus flexilis* James, extend along the mountain ranges from the Rocky Mts. of Colorado to Mt. Shasta in California; two, *Pinus monophylla* Torr. and *Juniperus Californica* Carrière, var. *Utahensis* Engelm. are endemic to the "Great Basin;" while *Cercocarpus ledifolius* Nutt., although occurring as a shrub both in the Rocky Mts. and in California, only here becomes a valuable tree.

Neither the Red Cedar nor the Aspen needs be considered here. A single small plant of the former was noticed; and it is evidently so rare throughout this region that it adds but little to the value of its forests. The Aspen borders all the mountain streams above 8,000 feet elevation, but, rarely surpassing fifteen feet in height and a few inches in diameter, is practically without value for its products. Further east in the Wahsatch Mts. this species is sometimes seen with stems two feet through; and it is largely used by the Mormons, who consider it valuable for flooring, turnery, etc.

Juniperus Californica, var. *Utahensis*, is the most common, and the most widely distributed of the trees of this region. It is found at lower elevations than any other tree, and alone descends into the valleys, where, at an elevation of 5,000 feet, it is often abundant, but less so than on the mountain sides, over which it spreads up to 8,000 feet elevation. It is a low, bushy tree, branching from the ground, with a stout trunk which rarely exceeds two feet in diameter; short and very stout branchlets, and thick shreddy bark. The wood, which is moderately hard, pale colored, and slightly aromatic, furnishes the common and cheapest fuel both for domestic use and for generating steam on the railroads and at the mines. The typical *Juniperus Californica* belongs to the California Coast Range, and the variety extends over the whole of the southern portion of the "Great Basin." In fruit this species will be readily distinguished by its dry one-seeded berry, the great thickness of the stony coating of the seeds; and from all other Junipers (as pointed out by Dr. Engelmann) by its 4–6-cotyledonous embryo. Without fruit it may be easily confounded with *Juniperus occidentalis* Hook., which species, however, has not been detected in Central Nevada. Like all the trees of the "Great Basin" this Juniper is of exceedingly slow growth. A specimen before me four and one-half inches in diameter shows

one hundred and five annual layers of growth, or an annual average increase of nearly $\frac{1}{15}$ of an inch.

Growing with this Juniper, above 6,000 feet elevation, and extending rather higher up the mountains, is *Pinus monophylla* Torr., the "Nut Pine" of Nevada and eastern California; but not to be confounded with an allied species, also bearing edible seeds, *Pinus edulis* Engelm., found from Colorado to New Mexico and Arizona. *Pinus monophylla* is a small tree, ten to twenty feet high, with reddish scaly bark, and is easily distinguished from other North American Pines by its *solitary*, glaucous, terete leaves (very rarely in pairs, and then semi-cylindrical). The wood is white, soft, light, and very resinous; it is more highly prized for making charcoal than that of any tree of this region. In slowness of growth *Pinus monophylla* does not essentially differ from the Juniper with which it is associated; a specimen that I have examined, from the locality which furnished the specimen of Juniper referred to above, is five and one-half inches in diameter and shows one hundred and thirteen annual layers of growth. The immense crops of large and delicately flavored seeds produced by this tree supply, as is well known, to the Indian tribes of the Great Basin their most important article of food. The value of this crop, and the excellent quality of the wood for charcoal, make this tree, in a mining region entirely destitute of coal, its most valuable vegetable production. The introduction of *Pinus monophylla* into the South of Europe as a subject for forest planting is worthy of consideration; it might flourish there on those dry and exposed hill sides which have been found so difficult to satisfactorily recover with any European tree. Its strictly pyramidal habit while young—a habit which it entirely loses with age—and the pleasing glaucous tints of its foliage commend this species to the lovers of ornamental conifers.

*Pinus Balfouriana** was only met with on Prospect Mountain, near Eureka, at an elevation of 7,500 feet, to the summit, 8,000 feet. Formerly the whole summit of this mountain was very generally covered with this species, but with few exceptions the trees have all been cut to supply the mines with timbering, for which purpose the strong and very close-grained, tough wood of this species is preferred to that of any other Nevada tree. The specimens seen were fifteen to thirty feet high, with trunks often two feet in diameter, pyramidal in outline, their lower branches still remaining; so that at a little distance they might readily be mistaken for spruces. The bark like the wood is reddish in color, very thick and deeply furrowed; that

* With the insufficient material at my disposal I cannot satisfactorily separate *Pinus aristata* Engelmann, from Murray's *P. Balfouriana*, the older name and founded on California specimens. *Pinus aristata* is an alpine plant discovered by Parry many years later in the Rocky Mts. of Colorado.

of the branches smooth and quite white. The short, falcate, appressed leaves persist for years, forming tufts of foliage a foot or more long at the ends of the naked branches; and this peculiarity has suggested to the lumbermen of the region the name of "Fox Tail Pine" for this species. *Pinus Balfouriana*, should it be found to retain in cultivation the peculiarities which characterize it on the mountains of Nevada, will be one of the most striking and interesting of the genus for ornamental planting.

Pinus flexilis, the Nevada representative of the Eastern White and the California Sugar Pine, is the largest and the most valuable timber tree of the central portion of the "Great Basin." I found large tracts of it on the Monitor Range, from 8,000 up to 10,000 feet elevation; and further to the northeast it gives their names to "White Pine" District, "White Pine" Range, etc. On the Monitor Range specimens fifty to sixty feet high, and from two-feet six to four feet in diameter were not infrequent, the trees gradually becoming smaller as the elevation increased, until at 10,000 feet they were little more than prostrate bushes a foot or two high. The fact that the finest specimens were found on the banks of the mountain streams, associated with *Populus tremuloides*, indicates that this species is more dependant on moisture than the other Nevada Conifers. It is the only tree of this region which is sawed into lumber. The wood is soft, white, and, although not free from knots, is of fair quality, and about intermediate between Eastern white pine and sugar pine.

Cercocarpus ledifolius, with *Populus tremuloides*, the only non-coniferous tree of this region, here attains its largest size and greatest age. It is common at 6,000 to 8,000 feet elevation, and next to the Juniper and the Nut Pine is the most common of Central Nevada trees. It is a small tree, ten to thirty feet high, with small evergreen leaves and brown scaly bark, in habit and general appearance not unlike a stunted apple tree. The wood of this tree, which is of a bright mahogany color and susceptible of a beautiful polish, is exceedingly hard, heavy and close-grained, but very brittle, and so liable to "heart shake" and difficult to work as to be useless in the arts. It is, however, sometimes employed for the bearings of machinery, where it is found to wear as well as metal; but it is as fuel that "Mountain Mahogany" (the name by which, owing to the color of its wood, *Cercocarpus* is universally known) has no North American equal. We are in the habit of considering that our Eastern Hickories produce the best fuel. The specific gravity of dry hickory is but ·838, while that of *Cercocarpus* is 1·117, so that, weight being the best test, as fuel it is worth 30 per cent. more than hickory. The amount of ash, too, left after

burning *Cercocarpus* is only $\frac{52}{100}$ of 1 per cent of the dry wood consumed, while that of hickory is $\frac{81}{100}$ of 1 per cent, three-tenths per cent more. *Cercocarpus* is probably the only North American wood which is heavier than water; and among the tropical woods employed in the arts and described by Lastett, but six equal or surpass it, the most conspicuous being the West Indian Lignum Vitæ (*Guaicum*) with a specific gravity of 1·243. As was to be expected, the growth of *Cercocarpus* was found to be exceedingly slow. An examination of several specimens from one to two hundred years old shows an average annual increase of wood only one-sixtieth of an inch in thickness. The largest specimen of this tree was seen on Prospect Mountain near Eureka, in New York Cañon, at an elevation of 7,000 feet. It was a low, much branched tree, about twenty feet high with a trunk rising six feet to the first branches. At three feet from the ground it had a girth of seven feet and five inches. If we suppose that its average growth had been as rapid as that of the younger specimens examined, this tree would have been 890 years old. It was probably much older. The rate of growth of trees is, after a certain age, in inverse ratio to their age; and it is perhaps permissible to suppose that the seed which produced this little tree had already germinated when the oldest living *Sequoia* on the Continent was still a vigorous sapling with its bi-centennial anniversary still before it.

Two shrubby plants of this region may be mentioned, which, from their beauty, are especially worthy of introduction to cultivation,—*Cowania Mexicana* Don., a large Rosaceous shrub, nearly allied to *Cercocarpus*, with elegant pinnatifidly-lobed leaves and large and very abundant yellow flowers; and a large shrubby *Spiræa*, *S. Millefolium* Torr., with the foliage of *Chamæbatia*, but a larger and more striking plant, and perhaps the most elegant of the genus.

It will have been seen that the forests of Nevada, consisting of a few species adapted to struggle with adverse conditions of soil and climate, are of immense age, and that the dwarfed and scattered individuals which compose them reach maturity only after centuries of exceedingly slow growth. On this account, and because, if once destroyed, the want of moisture will forever prevent their restoration, either naturally or by the hand of man, public attention should be turned to the importance of preserving, before it is too late, some portions of these forests. Large areas of forest-covered mountain ranges are still held by the General Government; and in view of the vast importance of their remaining wooded to serve as reservoirs of moisture, on the existence of which the future of this region must depend, it would seem wise and not perhaps altogether impracticable, to check, or at least to regulate, the terrible destruction of

forest, which follows, both on public and private domain, every new discovery of the precious metals.

A comparison of the arborescent vegetation of Nevada with that of the region lying directly east and west of the "Great Basin" may be interesting. Such a comparison will serve to more clearly demonstrate the remarkable poverty of the Nevada forests. It will afford, too, another illustration of the relation of moisture to forest distribution, especially with reference to the multiplication of species, which will be found to increase or diminish as the rain-fall is more or less abundant and more or less equally distributed.

In the territory between the 41st and 37th parallels of latitude, and extending from the eastern base of the Rocky Mts. to the foot of the western slope of the Sierra Nevada are three distinct belts of arborescent vegetation.* Beginning at the east there is: 1. The Rocky Mountain Region including, besides the main range, the Uinta and the Wahsatch, and embracing Colorado and the eastern half of Utah; 2. The Nevada Region, extending from the western base of the Wahsatch, to the eastern base of the Sierra Nevada, and embracing the western half of Utah and the whole of Nevada with the exception of the extreme northern and southern portions of the State; 3. The Sierra Nevada Region.

In the Rocky Mountain Region, to which in spite of its mid-continental position considerable moisture is attracted by the high peaks which everywhere dominate it, there are twenty-five trees and forty-eight shrubs, in all seventy-three species. In the Nevada Region, where, owing to its isolated position between high mountain ranges, the rain-fall is small and very unequally distributed, the number of species is reduced nearly one-half,—to thirty-eight; ten trees and twenty-eight shrubs. In the Sierra Nevada Region, to which the Pacific contributes a large although unequally distributed, snow and rain fall, the number of species is increased to eighty-nine; of these thirty-five are trees,† or three and a half times more than occur in the adjoining Nevada Region, and a third more than are found in the Rocky Mountain Region; and fifty-four are shrubs, or double the number of the Nevada Region.

The following table shows the arborescent‡ and frutescent species, so far as they are now known, which occur in these three Regions.

* For the purpose of the present comparison not only trees but all frutescent plants which may be expected to exceed four feet in height, and therefore as undergrowth to form an important element in the forest, will be included.

† *Pinus monophylla* Torr., although it has found a foothold on the eastern flank of the Sierra Nevadas, is not included among the trees of this region. This species, as well as *Artemesia tridentata*, are so peculiar to the Nevada Region that they cannot be properly considered a part of the Flora of the Sierra Nevada.

‡ Species which become large enough to be of economic value as timber trees, are designated by a *.

The Rocky Mt. Region.	The Nevada Region.	The Sierra Nevada Region.
Berberis Fendleri.	*Berberis Fremontii.*	
		Calycanthus occidentalis.
		Fremontia Californica.
Ptelea angustifolia.		
Rhamnus Californica.		*Rhamnus Californica.*
		Rhamnus alnifolia.
		Rhamnus crocea.
		Ceanothus cordulatus.
		Ceanothus integerrimus.
		Æsculus Californica.
*Acer grandidentatum.**		*Acer macrophyllum* *
Acer glabrum.	*Acer glabrum.*	*Acer glabrum.*
Negundo aceroides.		
Rhus glabra.		*Rhus diversiloba.*
Rhus aromatica, var. *trilobata.*	*Rhus aromatica*, var. *trilobata.*	*Rhus aromatica*, var. *trilobata.*
Robinia Neo-Mexicana.		
		Cercis occidentalis.
Prunus Pennsylvanica.		*Prunus subcordata.*
Prunus Virginiana.	*Prunus Andersonii.*	*Prunus emarginata.*
Prunus demissa.	*Prunus demissa.*	*Prunus demissa.*
Spiræa discolor, var. *dumosa.*	*Spiræa discolor*, var. *dumosa.*	*Spiræa discolor*, var. *dumosa.*
	Spiræa Millefolium.	
Neillia opulifolia.		*Neillia opulifolia.*
Rubus deliciosus.		*Rubus Nutkanus.*
Purshia tridentata.	*Purshia tridentata.*	
Coleogyne ramosissima.		
Cercocarpus parvifolius.		*Cercocarpus parvifolius.**
*Cercocarpus ledifolius.**	*Cercocarpus ledifolius.**	*Cercocarpus ledifolius.*
Cercocarpus intricatus.		
Cowania Mexicana.	*Cowania Mexicana.*	
		Adenostoma fasciculatum.
Rosa blanda.	*Rosa Californica*, var. *ultramontana.*	*Rosa Californica.*
Rosa blanda, var.	*Rosa blanda*, var.	
		Heteromeles arbutifolia.
Pyrus sambucifolia.		*Pyrus sambucifolia.*
Cratægus rivularis?		*Cratægus rivularis.*
Cratægus coccinea.		
Amelanchier alnifolia.	*Amelanchier alnifolia.*	*Amelanchier alnifolia.*
Peraphyllum ramosissimum.		
Philadelphus microphyllus.		*Philadelphus Lewisii.*
Fendlera rupicola.		
		Carpenteria Californica.
Ribes cereum.	*Ribes cereum.*	*Ribes cereum.*
Ribes aureum.	*Ribes aureum.*	*Ribes aureum.*
Ribes leptanthum.		*Ribes leptanthum.*
Ribes bracteosum.		*Ribes Menziesii.*
Ribes divaricatum, var. *irriguum.*		*Ribes oxyacanthoides.*
		Ribes sanguineum, var. *variegatum.*
Cornus pubescens.	*Cornus pubescens.*	*Cornus pubescens.*
		Cornus sessilis.
		Cornus Nuttallii.
		Garrya Fremontii.
Sambucus glauca.	*Sambucus glauca.*	*Sambucus glauca.*
Sambucus racemosa.		*Sambucus racemosa.*
Lonicera involucrata.	*Lonicera involucrata.*	*Lonicera involucrata.*
		Cephalanthus occidentalis.
Artemisia tridentata.	*Artemisia tridentata.*	
		Leucothæ Davisiæ.
		Arctostaphylos pungens, var. *platyphylla.*
		Rhododendron occidentale.
		Styrax Californica.
	Fraxinus anomala.	*Fraxinus dipetala.*
		*Fraxinus Oregona.**
Forestiera Neo-Mexicana.		

The Rocky Mt. Region.	The Nevada Region.	The Sierra Nevada Region.
		Eriodictyon glutinosum.
		Umbellaria (*Oreodaphne*) *Californica.**
Shepherdia Canadensis.	*Shepherdia Canadensis.*	
Shepherdia argentea.	*Shepherdia argentea.*	
	Shepherdia rotundifolia.	
Elæagnus argentea.		
Sarcobatus vermiculatus.	*Sarcobatus vermiculatus.*	
Atriplex confertifolia.	*Atriplex confertifolia.*	
	Spirostachys occidentalis.	
Celtis occidentalis.		
Celtis occidentalis, var. *pumila.*		
*Quercus undulata.**		*Quercus lobata.**
		Quercus lobata, var. *fruticosa.*
		*Quercus Douglasii.**
		*Quercus chrysolepis.**
		Quercus chrysolepis, var. *vacciniifolium.*
		*Quercus Sonomensis.**
		*Quercus Wislizeni.**
		*Quercus densiflora.**
		*Castanopsis chrysophylla.**
Betula occidentalis.		
Betula glandulosa.		
Corylus rostrata.		*Corylus rostrata*, var. *Californica.*
		Myrica Hartwegi.
Alnus incana.		*Alnus incana.*
Alnus viridis.		*Alnus rhombifolia.*
Salix longifolia.	*Salix longifolia.*	*Salix*, species.
Salix cordata.	*Salix cordata.*	*Salix*, species.
*Populus tremuloides.**	*Populus tremuloides.**	*Populus tremuloides.**
*Populus angustifolia.**	*Populus angustifolia.**	*Populus Fremontii.**
Populus balsamifera, var. *candicans.**	*Populus trichocarpa.**	*Populus trichocarpa.**
Ephedra trifurca.	*Ephedra trifurca.*	
*Pinus contorta.**		*Pinus contorta.**
Pinus contorta, var. *latifolia.**		
*Pinus ponderosa.**		*Pinus ponderosa.**
		Pinus ponderosa, var. *Jeffreyi.**
*Pinus edulis.**	*Pinus monophylla.**	
*Pinus flexilis.**	*Pinus flexilis.**	*Pinus flexilis.**
*Pinus Balfouriana.**	*Pinus Balfouriana.**	*Pinus Balfouriana.**
		*Pinus Sabiniana.**
		*Pinus tuberculata.**
		*Pinus monticola.**
		*Pinus Lambertiana.**
*Picea Engelmanni.**	*Picea Engelmanni.**	
Picea pungens (*Abies Menziesii* of the Colorado Flora).*		
*Abies subalpina.**		
*Abies concolor.**		*Abies concolor.**
		*Abies magnifica.**
		*Abies nobilis.**
		Tsuga Hookeri (*Abies Williamsoni.*)*
*Pseudotsuga Douglasii.**		*Pseudotsuga Douglasii.**
		*Sequoia gigantea.**
		*Libocedrus decurrens.**
		*Taxus brevifolia.**
		*Torreya Californica.**
Juniperus occidentalis, var.*	*Juniperus Californica*, var. *Utahensis.**	*Juniperus occidentalis.**
*Juniperus Virginiana.**	*Juniperus Virginiana.**	
73 species. 47 genera. 19 timber trees. 6 small trees. 48 shrubs.	38 species. 26 genera. 10 timber trees. 28 shrubs.	89 species. 51 genera. 31 timber trees. 4 small trees. 54 shrubs.

The following species, fourteen in number, are common to the three Regions:

Acer glabrum.	*Ribes aureum.*
Rhus aromatica, var.	*Cornus pubescens.*
Prunus demissa.	*Sambucus glauca.*
Spiræa discolor, var.	*Lonicera involucrata.*
Cercocarpus ledifolius.	*Populus tremuloides.*
Amelanchier alnifolia.	*Pinus flexilis.*
Ribes cereum.	*Pinus Balfouriana.*

The following species, twelve in number, are, in addition to those named above, common to the Rocky Mt. and Sierra Nevada Regions:

Rhamnus Californica.	*Alnus incana.*
Neillia opulifolia.	*Pinus contorta.*
Cercocarpus parvifolius.	*Pinus ponderosa.*
Pyrus sambucifolia.	*Abies concolor.*
Ribes leptanthum.	*Pseudotsuga Douglasii.*
Sambucus racemosa.	*Juniperus occidentalis.*

All the species of the Nevada Region extend into the Rocky Mt. Region with the exception of the following ten species:

Berberis Fremontii.	*Shepherdia rotundifolia.*
Prunus Andersonii.	*Spirostachys occidentalis.*
Spiræa Millefolium.	*Populus trichocarpa.*
Rosa Californica, var.	*Pinus monophylla.*
Fraxinus anomala.	*Juniperus Californica*, var.

Populus trichocarpa is the only species (with possibly the two willows) of the Nevada Region, which, in addition to the fourteen species common to the three Regions, extends into the Sierra Nevada. So that fifteen species of the Nevada Region reach the Sierra Nevada Region, while twenty-eight species extend into the Rocky Mountain Region, leaving but ten species peculiar to the Nevada Region. Of these *Fraxinus anomala* and *Shepherdia rotundifolia* are endemic; the other eight species extending south into Arizona.

The following genera common to the Sierra Nevada and Atlantic Forests, have no representatives in the mid-continental Flora:

Calycanthus.	*Leucothoë.*	*Tsuga.*
Æsculus.	*Rhododendron.*	*Torreya.*
Cercis.	*Styrax.*	
Cephalanthus.	*Myrica.*	

The following genera of the Sierra Nevada Region have no Eastern representatives:

Fremontia.	*Garrya.*	*Castanopsis.*
Adenostoma.	*Eriodictyon.*	*Sequoia.*
Heteromeles.	*Umbellaria.*	*Libocedrus.*
Carpenteria.		

The absence of arborescent and frutescent *Leguminosæ* from the three Regions, where herbaceous genera of this order are so largely represented, is remarkable, especially as they abound

farther south in New Mexico and Arizona. In the Rocky Mt. Region there is a single representative of this order, a *Robinia* nearly allied to those of the Eastern States; in the Nevada Region there is not a single frutescent *Leguminosa*, and in the Sierra Nevada but one species, a large shrubby *Cercis*. On the contrary the number of genera of frutescent *Rosaceæ*, many of them endemic and monotypic, is very large in proportion to other *Angiospermæ*. In the Rocky Mt. Region there are thirteen genera with nineteen species; in the Nevada Region seven genera with ten species; in the Sierra Nevada Region eleven genera with thirteen species; in all, fourteen genera with twenty-eight species. In all the United States east of the Mississippi River there are but ten woody Rosaceous genera, all represented in our three Regions with the exception of the Southern *Chrysobalanus* and *Neviusia*.

The comparison of these three Regions with reference to the distribution of the oaks will show how dependent these are on moisture. Oaks abound in both the Atlantic and Pacific forests, while in the Rocky Mt. Region there is but a single, exceedingly polymorphous species, which does not reach the Nevada Region, where no oak is known; nor has this genus, so far as I know, any foot-hold on the dry eastern slope of the Sierra Nevada. A few insignificant species extend, however, along the mountains of Arizona and New Mexico, where the precipitation of moisture is more regularly distributed than farther north, and serve to connect the oaks of the Pacific with those of the Atlantic forests.

The absence of *Pinus ponderosa* from the Nevada Region is remarkable. This species abounds in all the Rocky Mt. Region, and extends through New Mexico and Arizona to the Sierra Nevada, where, on the dry eastern slope, it constitutes in some of its forms fully three-quarters of the forests. It might therefore be naturally looked for on some of the higher mountains of Central Nevada, where, however, it has not yet been seen.

Pseudotsuga Douglasii, which also abounds in the Rocky Mt. Region, and on the higher mountains of New Mexico and Arizona, does not enter the Nevada Region. This is less remarkable, perhaps, than the absence of *Pinus ponderosa*, as this tree does not appear, in any numbers at least, on the eastern slope of the Sierras, and only reaches its noblest development in the humid climate of the northwest coast.

Juniperus Virginiana, the most widely distributed of North American trees, ranges from the Saint Lawrence River to Florida, and from the Atlantic to the Northern Pacific. It does not, however, enter the Sierra Nevada Region, and is extremely rare in Nevada.

LIV. — *On Ethylidenamine Silver Sulphate;* by W. G. XTER. Contributions from the Sheffield Laboratory of le College, No. LVI.

DEHYDE AMMONIA precipitates metallic silver from many salts almost as readily as from the nitrate. A mixture utions of silver sulphate and aldehyde ammonia produces ror when warmed, and at common temperatures evapo- to dryness, with but slight decomposition. The fact that hate solution decomposed less readily than the nitrate led hope that an investigation of the sulphate compound l throw more light on the constitution of silver amines. first experiments were made with ammoniacal aqueous ons of silver sulphate and aldehyde ammonia. Analyses d the crystalline product to be a mixture. Alcoholic nia was next used as a solvent, and the analysis of the rop of crystals showed nearly pure $Ag_2SO_4(NH_3)_4$, 0·6 ent of carbon was found and a solution of the crystals d for aldehyde. Aqueous solutions of silver sulphate large excess of aldehyde ammonia, over four molecules of tter to one of the former, yielded either mixtures or ammo- ilver sulphate. When, however, aldehyde ammonia is ved in a small quantity of water, and silver sulphate, in roportion of one molecule of the latter to four molecules former, is slowly added with constant agitation; and after hours the small black residue filtered off and the solution spontaneous evaporation, few or no crystals of the ammo- lphate form, but colorless transparent crystals separate, react strongly for aldehyde. At summer temperatures ar crystals, and at from 10° to 15° C. elongated crystals, minate.

e following analyses were made of carefully selected and lefined tabular crystals, which were from 2 to 5mm in ter, and which were freed as much as possible from the er liquor by blotting paper, then washed with alcohol nally with ether. They were considered dry when they ot lose weight on the balance in five or ten minutes.

ulated for $_4(C_2H_4NH)_4$	I.		II.		III.		Calculated for $Ag_2SO_4(C_2H_4NH)_3$ NH_3
6·61	6·68						
44·64	44·55	2	48·60	2	46·03	2	47·10
19·83	18·13	7·4	15·90	5·9	16·27	6·2	15·72
4·13	4·62		4·14		4·31		3·95
11·57	11·28						12·20
* * *	* * *	* *	* * *	* *	* * *	* *	* * *
10·04	10·24		10·50		10·39		10·15

Calculated for $Ag_2SO_4(C_2H_4NH)_2NH_33H_2O$		IV.		V.			
Ag	42·20	42·08	2	41·08	2	41·07	2
C	14·06	13·92	5·9	14·73	6·4	14·77	6·4
H	4·69	4·91		4·88			
N	10·90	10·64					
* *	* * *	* * *	* *	* * *	* *	* * *	* *
$3H_2O$	10·15			10·20			

The following results were obtained from crystals of an entirely different habit from those used in the preceding analyses, many of the crystals were one or two centimeters long, 4 or 5mm wide, and 1 to 3mm in thickness. They were freed from the mother liquor in the manner already described.

Calculated for $Ag_2SO_4(C_2H_4NH)_46H_2O$		VI.		Calculated for $Ag_2SO_4(C_2H_4NH)_4$	VII.			
S	5·40	5·26	1					
Ag	36·48	36·12	2	44·64	44·70	2	43·89	2
C	16·21	15·66	7·8	19·83	18·72	7·6	18·79	7·6
H	5·41	5·6		4·13	4·43		4·52	
* *	* * *	* * *	* *	* * *	* * * * *			
N	9·46	9·06	3·9					
$6H_2O$	18·24	17·29			17·67			

The atomic relations between the silver and carbon found are expressed by the figures following the percentages. The combustion for I was with lead chromate, and this carbon result may be too low, as subsequent duplicate combustions on another lot of crystals gave variations of 1 per cent of carbon. All the other combustions were made with oxygen, copper oxide, lead chromate and metallic copper. The silver in I and VI was weighed as chloride, and the other silver estimations were from weighing the residue left in the tray after the combustions, a method necessitated by the small quantity of material available. The duplicate VII shows the possibility of a mechanical loss. An error of 1 per cent in the silver found makes but a small difference in the atomic ratio between the silver and carbon, since the atomic weight of the former is high. The sulphur was precipitated as barium sulphate, and the nitrogen as ammonium platinic chloride, after separating the silver with hydrochloric acid. The water was determined by drying over oil of vitriol or caustic potash. A drop of sulphuric acid on a watch glass in the potash desiccator showed that there was a slight loss of ammonia on drying. The weights of substance for VI from one crop of crystals were made rapidly. 0·7395 gram was at once placed in the combustion tube whose anterior half was red hot; 0·438 gram was next put into water for the nitrogen estimation, and finally 0·533 gram of crystals, which

had become opaque white on edge, were dried to a constant weight for the water determination, and then used to find the sulphur content. The 17·67 per cent of water in VII was from drying 2·37 grams of crystals which had also become opaque while on edges.

Analysis VI corresponds with the theory, and the anhydrous material used in VII was from the same kind of crystals. The deficiency in the amount of carbon found may be ascribed either to impurities or a slight decomposition. I after losing water of crystallization, has essentially the same composition as VII. Both I and VI are hydrates of a compound analogous to ammonio silver sulphate, thus,

$$Ag_2SO_4(NH_3)_4$$
$$Ag_2SO_4(CH_3CH{=}NH)_4,\ 3H_2O$$
$$Ag_2SO_4(CH_3CH{=}NH)_4,\ 6H_2O$$

The name ethylidenamine silver sulphate is proposed for the present.

Analysis IV was made with hydrous crystals, and II with anhydrous substance from the same crop of crystals which were apparently of the same form as the crystals which gave results I. II and IV, give the formula,

$$Ag_2SO_4(CH_3CH{=}NH)_3NH_3,\ 3H_2O.$$

Leaving out the $3H_2O$ we see that the substance has the same composition as a mixture of 3 molecules of $Ag_2SO_4(C_2H_4NH)_4$ and one molecule $Ag_2SO_4(NH_3)_4$. But if we suppose it a mixture of $Ag_2SO_4(C_2H_4NH)_4$, $3H_2O$ and $Ag_2SO_4(NH_3)_4$ we find that the water is 8·1 per cent and does not accord with the water found, and the conclusion is that the substance analyzed was not a mixture, but a compound containing three ethyliden groups, and answering to the formula already given. III and V of two different crops of crystals appear to be mixtures of $Ag_2SO_4(C_2H_4NH)_4$, $3H_2O$ and $Ag_2SO_4(C_2H_4NH)_3NH_3$, $3H_2O$. Ethylidenamine silver sulphate is soluble in water and yields aldehyde when treated with acids. The hexhydrated salt loses water more readily in dry air than the trihydrated.

ART. LV.—*Notes on the Satellites of Saturn*; by MARIA MITCHELL.

THE object glass of the telescope used in the observations which follow is of twelve and one-third inches diameter. Its definition is good.

The telescope is used in such observations as its very imperfect mechanism will allow; these are observations of the conjunctions of the satellites with the edge of Saturn's ring, of size and color, and of differences of right ascension.

The last are made by connecting with the chronograph, and recording the time of passage of the satellites over a fixed wire.

In the course of these observations such different relative magnitudes have been given to the small satellites, on different evenings, as to lead to the suspicion that some of them are variable.

The sparkle of Tethys and the grayish blue color of Rhea make it seem unlikely that small stars can have been taken for these two satellites; in the case of Enceladus and Dione mistakes are more easily made; but the rapid motion of Enceladus soon establishes its identity. The most noticeable changes are in Rhea.

In 1877, Rhea is recorded as small on Nov. 30th; as dull on Dec. 3d; as blurry and large, Dec. 14th; and as ruddy, Dec. 18th. In 1878 Rhea is recorded as faint Oct. 3d and Oct. 16th: as bright on Oct. 25th, and on Dec. 3d it is called nearly as bright as Titan.

1877, Oct. 5.—Rhea was in conjunction with the preceding edge of the ring at 8^h 58^m 29^s P. M. Two small satellites following the planet were in conjunction at the same time; the smaller one moved rapidly toward the ball.

1877, Oct. 6.—Two small satellites were nearly in conjunction with the edge of the preceding ring at 9^h 28^m P. M. The smaller of these was probably Dione; the larger may have been a star.

1877, Oct. 9.—10^h 8^m P. M. Tethys is moving away from the ball and has passed conjunction with the ring. Another satellite, probably Enceladus, is coming in, and is nearly up to conjunction with the following edge of the ring.

1877, Oct. 13.—At 10 P. M., two small satellites were seen to be nearly together following Saturn, the space between them being $1''\cdot5$. At 10^h 53^m 31^s, the two satellites could not be separated with a power of 400. The two were of the same size. At 11^h 20^m 31^s, the satellites could be seen separated. These may be Tethys near greatest elongation, and Enceladus approaching the planet.

1877, Oct. 14.—Rhea was in conjunction with the preceding edge of the ring and above the ring at 9^h 9^m 30^s.

1877, Oct. 23.—Rhea was again in conjunction with the preceding edge of the ring and above it, at 10^h 29^m 22^s.

1877, Nov. 6.—Tethys was in conjunction with the preceding edge of the ring at 9^h 31^m 30^s.

1877, Nov. 7.—Tethys was in conjunction with the following edge of the ring and above the ring at 9^h 22^m 50^s.

1877, Nov. 13.—Dione was in conjunction with the following edge of the ring at 8^h 44^m 6^s.

1877, Nov. 14.—Titan was in conjunction with the preceding edge of the ring at 8^h 7^m 6^s.

1877, Nov. 16.—Enceladus was in conjunction with the following edge of ring and beneath it at 9^h 51^m 6^s.

1877, Nov. 17.—The seeing was excellent. Two satellites, probably Tethys and Enceladus, were seen as one at 6^h 29^m 24^s. In twenty minutes they had separated 3″. Rhea was in conjunction with the following edge of ring at 6^h 45^m 21^s and 3″ below the ring. Dione was nearly at conjunction with the preceding edge of ring at 7 P. M.

1877, Nov. 30.—Titan was in conjunction with the preceding edge of the ring at 7^h 17^m 1^s. A small satellite (Tethys?) a little past conjunction and above the ring at 8^h 10^m.

1877, Dec. 12.—Tethys was in conjunction with the preceding edge of the ring and below it at 6^h 48^m 49^s.

1877, Dec. 14.—A small satellite preceded the ring by one and three-fifths the measurement of the preceding ansa. Was this Mimas? The time was 7^h 34^m.

1877, Dec. 16.—Titan was in conjunction with the preceding edge of the ring at 6^h 19^m 36^s.

1878, Jan. 12.—5^h 50^m to 6 P. M. The ring of Saturn appeared as a line. Titan preceded the planet and three small satellites followed, two of them estimated to be a second of arc only asunder. The distance from the following edge of the ring to the two satellites so closely together was nearly twice that from the ball to the edge of the ring.

1878, Jan. 16.—Observations began at 4^h 50^m P. M. The ring was seen as a line at 5^h 12^m, its following portion being seen first. A bright spot was seen on this portion of the ring.

1878, Jan. 18.—The night was very fine, and at 6 P. M. the ring could be seen as a ring. The preceding portion of the ring was sharper than that following. On the following portion a bright spot was seen.

1878, Jan. 29.—At 5^h 25^m P. M. the ring could be seen as a bright line across the planet. Titan preceded the planet and four satellites followed. At 6^h 40^m a very faint satellite was seen (Tethys?) nearly up to conjunction with the ring and moving toward the ball.

1878, Feb. 7.—6^h 30^m P. M. Points of light could be seen preceding Saturn, but the continuity of the ring could not be kept. A small point of light, possibly a satellite preceded the ring. Rhea and Titan followed the planet.

1878, Oct. 3.—8^h 40^m P. M. Two satellites, supposed to be Rhea and Dione, are nearly in conjunction and preceding the planet. Two others follow, Tethys moving out and Enceladus (?) nearly

at conjunction with the ring. Of the four satellites, Tethys is the brightest.

1878, Oct. 16.—Titan was in conjunction with the edge of the following ring at 7^h 38^m; above the ring.

1878, Oct. 24.—Titan was seen emerging from the ball of Saturn at 9^h 16^m 30^s. 7^h P. M.—A very faint satellite was seen by glimpses, following, nearly in conjunction with the ring.

1878, Oct. 25, 7 P. M.—Titan and another satellite supposed to be Rhea were nearly in conjunction separated by 7″. A very small satellite precedes the tip of the ring.

1878, Oct. 28.—Tethys was in conjunction with the edge of the following ring and below at 7^h 37^m P. M.

1878, Oct. 29.—Tethys was nearly at conjunction with the preceding ring and above at 7 P. M.

1878, Nov. 9.—At 8^h 18^m 3^s Titan was seen to emerge from the planet. It was wholly detached from the planet in twenty minutes. At 9^h 25^m P. M., a small satellite was seen, nearly at conjunction with the following ring.

1878, Nov. 13.—Six small bodies preceded Saturn. Of these, Titan, Rhea, Tethys and Dione could be identified. At 7^h 48^m P. M. the satellite supposed to be Rhea is distant from the preceding ring 6″, Tethys is distant 1″.

1878, Nov. 14.—7^h 30^m P. M. A very small satellite follows Saturn, distant about 3″.

1878, Nov. 26.—Titan and a satellite supposed to be Rhea were asunder 6″ 3′ at 7^h 22^m. If this satellite was Rhea, it was unusually bright. Tethys and a very faint satellite precede Saturn, the latter is probably Enceladus.

1878, Nov. 29.—At 6^h 15^m P. M. a small satellite preceded Saturn and three others followed. Of those following, that which was nearest to Saturn could not be found at 9 P. M., and the second in distance from Saturn had moved in; the latter was probably Tethys.

1878, Dec. 3.—Dione was in conjunction with the following edge and above the ring at 7^h 46^m 34^s P. M. A small satellite was seen by glimpses, following at a distance of 6″ from the ring.

1878, Dec. 6.—At 6^h 25^m a small satellite followed Saturn distant 7″ from the edge of the ring. This satellite could not be found at 7^h 55^m although the seeing was much better. At 7^h 55^m a small satellite having the peculiar sparkle of Tethys, was seen a little beyond the following edge of the ring, and moving away from the ball.

1878, Dec. 13.—Titan and three small satellites precede the planet, probably Rhea, Tethys and Dione. Of the three, Tethys is the brightest at 6^h 57^m. It moves away from the ball. At 8^h 57^m two of these satellites could not be separated with a power of 230. I suppose them to be Tethys and Rhea.

1878, Dec. 16.—9^h 5^m P. M. Tethys was nearly up to conjunction with the ring; moving toward the ball. Rhea was large and dull in color.

Observatory of Vassar College.
Longitude from Greenwich, 4^h 55^m $33{\cdot}9^s$.

ART. LVI.—*On the Force of Effective Molecular Action*; by Professor W. A. NORTON.

[Continued from page 358.]

FOR the critical curve the molecular repulsion has very nearly the constant value, $0{\cdot}0052\frac{m}{r^2}$, from $x=3r$ to $x=7{\cdot}5r$; and according to Dr. Andrews, the pressure of condensation at the critical point for carbonic acid gas was seventy-five atmospheres. These data give for the molecular repulsion answering to one atmosphere, $\dfrac{0{\cdot}0052\frac{m}{r^2}}{75}=0{\cdot}0000693\frac{m}{r^2}$. This should then be the value of the minimum repulsive ordinate, that obtains when $x=3r$, in the curve for water at the point of ebullition (212° F.). This result gives for this curve $k=4{\cdot}931$. In this curve the same molecular repulsion occurs again at $x=115r$. Now taking 1581 for the ratio of expansion by volume of water converted into steam at 212° F., and for the distance between the effective molecules of the steam, $115r$, and putting $y=$ distance of the inner surface of the effective envelope from the center of the molecule, I have

$$\frac{115r+2r+2y}{3r+2r+2y}=\sqrt[3]{1581};$$

which gives $y=2{\cdot}76r$. This calculation proceeds on the supposition that the effective molecules have the same size in the vaporous as in the liquid state, but theoretically they should be larger; and we shall see in the sequel that the probable value of the diameter of the molecules of steam is $42{\cdot}25r$. If we adopt this estimate, the ratio of expansion by volume, 1581 to 1, gives for the diameter of the liquid molecule at 212° F., $10{\cdot}5r$.

Let us now see how far the well known laws of gases may be deduced from our molecular formula.

(1). *Avogadro's Law*, relative to the simple gases; that all simple gases contain in the same volume, at the same pressure and temperature, the same number of ultimate molecules. This law follows from the fact that for the large distances between contiguous molecules, that obtain in gases, the effective repulsion is very nearly the same at the same distance for all the values of k that can answer to the different gases; together with the large size of the effective gaseous molecules. The entire possible range of value for k, for gases and vapors, is from 0 to $4{\cdot}934$; since it is only between these limits that the effective molecular force is repulsive at all distances. We

have already seen that when $k=4\cdot931$, and $x=115r$, the effective repulsion is $0\cdot0000693p$; and that this answers to one atmosphere of external pressure. When $k=0$ and $x=115r$, the effective repulsion is $0\cdot00007561p$; and the distance x at which the repulsion becomes $0\cdot0000693p$ is $120r$. But the distances between the centers of the molecules must be much greater than these values of x. It will soon appear that the law of Mariotte requires that the radius of the effective gaseous molecule, under a pressure of one atmosphere, be not less than $31r$. This gives for the distance between the centers of the molecules, under this pressure, $177r$ when $k=4\cdot931$; and $182r$ when $k=0$. Now $\left(\frac{182}{177}\right)^3=1\cdot086$. This is the highest ratio of volumes of two simple gases, under atmospheric pressure, that would be theoretically possible; unless the effective size of the molecules be supposed to diminish as k increases. But this is only an ideal extreme result. It will appear in the sequel that the values of k for the simple gases, oxygen, hydrogen and nitrogen, for which Avogadro's law, for a constant pressure and temperature, has been experimentally established, are included within narrow limits (probably 2 and 3). It thus becomes apparent that the extreme ratio of the number of molecules in the same volume cannot exceed $1\cdot013$, and may be much less.

(2.) *Avogadro's Law*, relative to compound gases; that the same volumes of these gases contain the same number of molecules, and the same number as equal volumes of the simple gases. The ordinary physical conception is that compound molecules are formed by the union of simple molecules, or of a certain number of their constituent atoms, and that these occupy the same volume that the simple molecules did. In some instances of chemical combination it necessitates the supposition that the formation of each new compound molecule is a result of the breaking up of several molecules of the combining substances. It also involves the improbable hypothesis that the space physically occupied by a molecule is wholly independent of the number of its constituent atoms. Upon the conception of variable ultimate molecules adopted in this and my previous paper, Avogadro's law simply implies that in the act of combination the effective molecules suffer a certain diminution of size, by the collapse of their envelopes. The same number of atoms may thus physically occupy the same volume as if they were closely to unite and form a compound molecule, upon the ordinary hypothesis. Thus in the formation of aqueous vapor by the combination of two volumes of hydrogen with one volume of oxygen, forming two volumes of the compound, a condensation of the individual molecules would take place, and as the result two ultimate

molecules of hydrogen and one of oxygen would occupy the same volume that three molecules of either gas did before the combination. It is to be observed, in confirmation of this view of the process of combination, that the reduction in the size of the effective molecules, would be attended with an increase in the ratio k, and a consequent increase in the value of the attractive term in equation (1), for the same value of x (or graphically, a rise of the curve of effective molecular action; see fig. 3).

The compound should therefore be a more condensable gas, or vapor. We have already obtained for aqueous vapor, at 212° F., $k=4{\cdot}931$; and it will appear hereafter that for oxygen, hydrogen, or nitrogen, the value of k must fall below 4, and is probably near 2. To obtain the theoretical size of the effective molecules of aqueous vapor, we have the equation $\frac{118r+62r}{115r+y'}=\sqrt[3]{\frac{3}{2}}$. This gives $y'=42{\cdot}25r$, and radius of molecule$=21{\cdot}12r$. The distance between the centers of contiguous molecules will be $157{\cdot}25r$. In this equation $118r$ is the distance between contiguous molecules of oxygen or hydrogen before condensation, and answers to $k=2$, nearly; and $62r$ is the diameter of one of the molecules (see page 436): $115r$ is the distance between the same molecules after the condensation into aqueous vapor; when k has been increased to $4{\cdot}931$.

In all combinations of simple gases the degree of condensation that occurs is expressed by the ratio of the number of atoms in the "compound molecule," as shown by the ordinary molecular formula, to 2, the assumed number of the constituent atoms of "the molecule" of a simple gas. In this statement it is supposed that the constituent gases before combination are in the perfect gaseous condition, like oxygen, or hydrogen, and that the compound gas has the temperature at which it is in a similar condition; so far as these two suppositions are implied in Avogadro's law.

Mariotte's, or Boyle's Law, of the uniform compressibility, by volume, of gases under increasing pressure. Upon the present theory this law should obtain if the effective molecular repulsion be inversely proportional to the volume occupied by the same number of molecules, or to the cube of the distance between the centers of contiguous molecules. For each molecule would then be the center of a system of recurring impulses propagated in waves by the interstitial luminiferous ether, proportional in intensity to the number (n) of molecules in a unit of volume, and every line radiating from any point of the enclosure into the body of gas would sensibly intersect a molecule at a greater or less distance. To obtain the entire impulsive action (P) on the point considered, we have then only to conceive a hemisphere traced around this point, and that all the points of

its surface are centers of radiating impulses proportional in intensity to n, and propagated according to the law of inverse squares. P should then be proportional to the intensity of the radiation at the points of the hemisphere, and therefore to n.

Now the expression for the effective molecular repulsion (equ. 1) consists of two terms of which the first, or attractive term, becomes relatively very small at the molecular distances that obtain, at moderate pressures, in gases (p. 346). The repulsive term, $\frac{m}{x^2}$, gives, then, very nearly the effective force, at such pressures; and more nearly in proportion as the ratio $\frac{n}{m}$ is smaller. Mariotte's law should then be satisfied, for considerable variations of pressure if the term $\frac{m}{x^2}$ should vary inversely as the cube of the distance (x') between the centers of contiguous molecules; that is, if $\frac{1}{x^2} \div \frac{1}{x'^3}$. If we denote by h the radius of the effective molecule, $x' = x + 2h$. As we are not in a position to determine à priori the law of variation of the size of the molecule under varying pressures, the only alternative is to adopt the hypothesis that $\frac{1}{x^2} \div \frac{1}{x'^3}$, deduce a series of values of the diameter $2h$, of the effective molecule that shall be in conformity with this hypothesis, and then test the results and hypothesis by deducing the theoretical deviations from the law of Mariotte in special cases, and comparing them with the deviations experimentally determined. Now I find that the hypothesis that $\frac{1}{x^2} \div \frac{1}{x'^3}$ is satisfied by the following values of $2h$, viz: 62·10, 62·00, 61·26, 60·32, 58·96, 57·12, 54·70, 51·58, 47·54, 42·24, 35·14, 30·53, 24·74, 16·89, 12·57,— answering respectively to the following values of u (equ. 2): 120, 115, 100, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, and 3. Theoretically one gas differs from another in the value of k, and the larger this ratio the greater should be the deviations from the law of Mariotte, which strictly is fulfilled only when $k=0$, and so the attractive term in our formula equal to zero. These deviations should also increase as the pressure increases, since the attractive term will become relatively greater. The more permanent simple gases (oxygen, hydrogen, etc.), for which the law of Mariotte holds good over the greatest range of pressure, should then have the smallest values of the ratio k; and compound gases the larger values (see p. 435). We may now assume, as a basis for an approximate calculation, that the molecules of all the gases have equal diameters under equal

pressures, and we may then compute for any supposed value of k the volume that should obtain under any supposed pressure, and compare it with the value that would result if the law of Mariotte were strictly fulfilled. Dr. Andrews, in his Bakerian Lecture on the continuity of the gaseous and liquid states of matter, states that under a pressure of forty-nine atmospheres, at the temperature 13°·09 C.; the volume of carbonic acid gas was "about $\frac{3}{5}$ of the volume that Mariotte's law would give." The critical temperature of the gas he found to be 30°·92 C., and we have seen (p. 357) that for the critical curve $k=4·7$. This gives for the temperature 13°·09 C. $k=4·75$ (very nearly). Now calculating the volume for this value of k, and under a pressure of 49 atmospheres, I obtain 0·648 of the volume (V) Mariotte's law would give. Experiment gave 0·60V. By what has already been stated (p. 434), the actual diameter of a molecule of carbon-dioxide, under the pressure of one atmosphere, should be less than $62r$, the diameter assumed for molecules of oxygen and hydrogen. Taking it $52r$, I have deduced from the hypothesis that $\frac{1}{x^2} \div \frac{1}{x'^3}$ another series of values of the diameter $2h$; and making a new calculation, I find the theoretical volume $=0·613$V. The ratio of condensation from the perfect gas in the production of carbon dioxide (see p. 435) would lead us to conclude that the diameter of the molecule, at the temperature 13°·09 C. would be less than 50 (possibly as low as 40). Taking it at 40 I obtain by estimation the theoretical volume $=0·58$V. I have made other similar test calculations, with the aid of Dr. Andrews' experimental determinations with similar results.

Gay Lussac's Law of the uniform variation of the volume of a gas under constant pressure, as well as of the elastic force under a constant volume, resulting from a change of temperature. This may be deduced from the principle which gives Mariotte's law, that the molecular repulsion varies inversely as the volume, and the principle that it is directly proportional to the coefficient of repulsion (m), which must be proportional to the absolute temperature. We have already seen that the elastic pressure of a gas should be proportional to the molecular repulsion (F). Now for the range of pressure for which the law of Mariotte holds good, we have

$$F=f=\frac{m}{x^2}=\frac{m'}{x'^3}=\frac{Cm}{x'^3}.$$

The volume is represented by x'^3. If x' becomes $x'+dx'$, the volume becomes $(x'+dx')^3=x'^3+3x'^2dx'$ (very nearly). Thus the increase of volume is $3x'^2dx'$; and the ratio of increase $\frac{3x'^2dx'}{x'^3}$. But the increment dx' is due to an increase of tem-

perature, and must answer to dm, while f remains constant. Thus $dx'=\frac{dm'}{3fx'^2}$, and therefore the ratio becomes

$$\frac{dm'}{fx'^3}=\frac{dm'}{m'}=\frac{dm}{m}.$$

For the case in which the volume is constant, while the temperature rises,

$$df=\frac{dm'}{x'^3}\text{; and }\frac{df}{f}=\frac{dm'}{fx'^3}=\frac{dm'}{m'}=\frac{dm}{m}.$$

Thus the ratio of the increase of volume is equal to the ratio of the increase of elastic pressure. We may assume that from a certain absolute temperature, T, m increases uniformly for each increment, 1° of temperature. Let t denote the actual temperature above T; then $m=c't$, and $\frac{dm}{m}=\frac{dt}{t}$. From which it appears that above T the increase of volume, or of the elastic pressure, takes place uniformly; that is, is equal in amount for equal increments of temperature. We may conclude from this investigation that Gay Lussac's law holds good only for that range of pressure and temperature within which the law of Mariotte is fulfilled; and that it is not strictly true for the more compressible gases and vapors, except at temperatures considerably above the point of condensation.

Specific Heat of Gases.—When the temperature of a gas is raised 1°, without change of volume, the heat is expended in exalting the vibratory state (i. e. the dynamic energy) of the molecular envelopes, and in augmenting their potential energy by expansion. It is obvious, then, that the specific heat of a gas, under a constant volume, should be some function of the ratio, k, since upon this must depend at a given temperature, the number of molecules in the unit of volume, and the mechanical condition of each molecule. The theoretical indications are that the specific heat of different gases, for the unit of volume, is directly proportional to the value of k; but as these cannot be adequately presented here we will assume this as an hypothesis and test it by the quantitative results to which it leads. To state the hypothesis with more precision, it is that the specific heat of a gas, when the volume is constant and the *initial* elastic pressure is one atmosphere, is, for a unit of volume, proportional to the value of k—it being understood that in the case of a compound gas the value of k considered is that which which obtains when the molecules are in the condition that immediately results from the formation of the gas from its constituents, and at the temperature at which the ratio of condensation is that proper to the gas.

When a gas is allowed to expand under a constant pressure, an additional amount of heat is expended in the work of this expansion in opposition to the external pressure. Now if n were equal to m the amount of heat thus expended should equal that which would be expended on the molecular envelopes. Let U denote the entire amount of heat expended when the pressure is constant, u that expended in the work of expansion, and u' that expended on the molecules directly; and we have $U=u+u'=u+su$. Each term is a function of the temperature, t; and, differentiating, we have $dU=du+sdu$. But we have seen that du equals the value which sdu would have if k, or $\frac{n}{m}$, were equal to unity. Denote it by e, and we obtain $dU=e+se$. But, since the specific heat under a constant volume is proportional to k, $\frac{se}{e}=\frac{k}{1}$; and thus $s=k$. This value of s gives $dU=(1+k)e$, and $sdu=ke$; from which $\frac{dU}{sdu}=\frac{1+k}{k}$. This is ratio of the specific heat under a constant pressure to the specific heat under a constant volume.

Let us now subject these theoretical results to the test of calculation. According to Pouillet the specific heat of aqueous vapor, under a constant volume, is 1·9600, and that of a mixture of one volume of oxygen and two volumes of hydrogen, 0·9277. The ratio of these is 2·113. For aqueous vapor we have seen that $k=4·93$. Thus, $\frac{4·93}{2·113}$ $(=2\frac{1}{3})$ should be the value of k for the mixture of oxygen and hydrogen before condensation into aqueous vapor. This result, as will appear in the sequel, is in accordance with the results of Professor Pictet's experiments on the liquefaction of oxygen and hydrogen.

Taking the specific heat of carbon-dioxide, under a constant volume at 1·26, we have $\frac{1·26}{0·9277}=1·36$, and $1·36\times2\frac{1}{3}=3·17$. This is the value of k for this gas under a pressure of one atmosphere, and in the condition in which it exists as the immediate product of the combustion of carbon. It is here tacitly supposed, in accordance with fact, that the specific heat of the gas, for equal volumes, and under the pressure of one atmosphere, is the same, when in the state of a vapor, at whatever temperature it is supposed to be formed from a liquid. Theoretically there should be a tendency to this state of things, since when the temperature is higher the number of molecules in the unit of volume, at the same elastic tension, is less, but at the same time the specific heat of each molecule should be greater, owing to the increased size of its envelope, and its

consequent greater liability to expansion under the operation of the heat energy. For olefiant gas we have $\frac{1\cdot553}{0\cdot9277} = 1\cdot674$; and $1\cdot674\times2\frac{1}{2}=4\cdot2$, the theoretical value of k for this gas. These results enable us to test our expression for the ratio of the specific heats under a constant volume, and at a constant pressure, viz: $\frac{1+k}{k}$. For the mixture of oxygen and hydrogen $\frac{1+k}{k}=\frac{1+2\frac{1}{3}}{2\frac{1}{3}}=1\cdot430$. The experimental value is $1\cdot410$. For carbon-dioxide $\frac{1+k}{k}=\frac{3\cdot17+1}{3\cdot17}=1\cdot315$. According to experiment it is $1\cdot338$. For olefiant gas the ratio is $\frac{4\cdot2+1}{4\cdot2}=1\cdot24$, the same as obtained by experiment. For oxide of carbon I get $k=2\cdot60$ and ratio of specific heats $=1\cdot38$; experiment gives $1\cdot428$. For oxide of nitrogen $k=3\cdot396$ and ratio of specific heats $=1\cdot294$; experiment gives $1\cdot343$.

Professor J. Clerk Maxwell (Nature, March 10, 1875, p. 375) admits that the kinetic theory of gases has encountered a serious dilemma in the attempt to determine specific heats. He says, "We learn from the spectroscope that a molecule can execute vibrations of constant period. It cannot therefore be a mere material point, but a system capable of changing its form. Such a system cannot have less than six variables. . . . But the spectroscope tells us that some molecules can execute a great many different kinds of vibrations. They must therefore be systems of a very considerable degree of complexity, having far more than six variables;" and "every additional variable increases the specific heat, whether reckoned at constant pressure or at constant volume. But the calculated specific heat is already too great when we suppose the molecule to consist of two atoms only." The present theory encounters no such difficulty, since it regards the heat and light vibrations as pertaining to the atoms of the molecular envelopes, and the number of these is indefinitely great, and the determination of the specific heat requires no hypothesis of a definite number of atoms to be made. In the same connection Professor Maxwell has the following remark: "And here we are brought face to face with the greatest difficulty which the molecular theory has yet encountered, namely, the interpretation of $n+e=4\cdot9$. He had previously remarked " that $n+e$, for air and several other gases, cannot be more than $4\cdot9$. For carbonic acid (?) and steam it is greater." Now $n+e$ answers to the ratio, k, on the present theory, and we have seen (p. 433) that this is $4\cdot93$ for steam, and less than $4\cdot9$ for the gases.

Diffusion of Gases.—The law of variation of the molecular repulsion, at the distances between gaseous molecules, given by equ. (1), leads to the result that if one layer of such molecules moves over another, so that those on one side of the plane of separation are opposite the vacant spaces between those on the other side, a force of effective repulsion directed toward this plane will supervene, which will operate to diffuse each set of molecules into the volume occupied by the other. Did space admit, we might show that when all the circumstances of the case, and the resistances in operation, are duly considered, the diffusion thus originating should conform to the known laws of diffusion; as that the velocity of diffusion of the individual molecules is inversely proportional to the square root of the molecular weights, &c. The force of diffusion of liquid molecules has a similar origin. Upon this view the force of diffusion is incidental to the inevitable internal agitations occurring in fluid masses; and may be brought into more lively action by artificial disturbances. The molecular repulsive or heat energy consumed in such effects is restored to the mass by the subsidence of the individual movements, perpetually recurring.

Comparison of the present with the kinetic theory of gases.—The theory of gases which has now been deduced from the general expression for the force of effective molecular action (equa. 1, or 2), is no less dynamical in its essential character than the kinetic theory. The dynamical system conceived to be in operation is, upon the one view, the translatory wave movements and atomic vibrations of the interstitial ether and ethereal atmospheres of the molecules, and upon the other, the movements of translation of the molecules themselves, and the vibrations of their constituent atoms. The doctrine of Energy, and the principles of the Mechanical Theory of Heat, are as applicable to the one as to the other theory. The essential correspondence of the two theories is abundantly evident from the fact that with equa. (1) an expression for the elastic pressure of a gas may be obtained that is a counterpart of that given by the equation of Clausius, viz: $p\mathrm{V}=\frac{2}{3}\mathrm{T}-\frac{2}{3}\Sigma\Sigma\frac{1}{2}\mathrm{R}r$. This may be inferred from the general consideration that the impulses upon any point, O, of the enclosure, of an ethereal wave in which the velocity of the radial pulsation increases from zero to a maximum, u, and then decreases to zero, is analogous to the impulse of a gaseous molecule whose velocity, u' is reduced to zero, and then restored in the recoil—the ethereal waves and the gaseous molecules alike impinging on the point from every variety of direction. To show it conclusively, let it be borne in mind that the central atoms of the molecules of the gas may, for each point O, of the enclosure, be conceived to be uniformly distributed over the surface of a hemisphere described around this point, so

that each elementary part of the surface will be occupied by one such atom, and so will be a center of radiation of wave-impulses propagated to O (p. 436). Now let u be the maximum velocity of pulsation of the ethereal atoms in any wave, at the point O; m the mass of ether effective in the pulsation; s the minute space (equal to half the length of a wave) over which m moves while the velocity is increasing from zero to u, or decreasing from u to zero; and p_1 the mean impulsive force taking effect over the space s. Then for the wave impulses propagated along the normal at O, $p_1 \times 2s = mu^2$. Let n_1 denote the number of successive waves in the space, 1, and take for the unit of time the interval employed by the wave in traversing the distance, 1; and we have $n_1 = \frac{1}{2s}$ and $p_1 \times 2s \times \frac{1}{2s} = n_1 mu^2$, or $p_1 \times 1 = n_1 mu^2$. But $p_1 \times 1$ is the impulsive work of the waves in the unit of time, and may be taken as p', the force of pressure on an elementary area at O, due to the successive waves propagated along the normal at O. Now for a wave coming from a direction inclined under any angle φ' to the normal, the normal impulse will be $p' \cos\varphi'$, and the normal velocity of pulsation will be $u \cos\varphi'$. Thus $p' \cos\varphi' = n_{,} mu^2 \cos^2\varphi'$; and for n' molecules having this angle of direction, $n'p' \cos\varphi' = n'n_{,} mu^2 \cos^2\varphi'$. For the entire normal impulse at O, or the elastic pressure, p, on an elementary area at O, we have then, $p = \Sigma n'n_{,} mu^2 \cos^2\varphi$. But the gaseous molecules lying in any angle of direction, φ, around the normal, form an elementary zone of the hemisphere, whose breadth is $d\varphi$, and altitude, in the normal direction, $d \cos\varphi$, or $\sin\varphi d\varphi$. If then n represent the number of molecules in the entire hemisphere, $n' : n :: \sin\varphi d\varphi : 1$; and $n' = n \sin\varphi d\varphi$.

$$\text{Thus } p = \int_0^{\frac{\pi}{2}} nn_{,} mu^2 \cos^2\varphi \sin\varphi d\varphi = nn_{,} mu^2 \left(-\frac{\cos^3\varphi}{3}\right)_0^{\frac{\pi}{2}} =$$
$$\frac{nn_{,} mu^2}{3} = \tfrac{2}{3} \cdot \frac{nn_{,} mu^2}{2}. \quad \text{Now } \frac{nn_{,} mu^2}{2}$$

is the entire living force, or energy, of all the ethereal waves occupying at any interval of time the space unity on all the lines radiating from O; or included within a hemisphere traced around O with the radius 1. Calling this E, we have $p = \frac{2}{3}$E. But the hypothesis, which has been tested by quantitative determinations (p. 437), that the repulsive term in equ. (1) varies inversely as the cube of the distance, x', between the centers of the molecules, gives the same law of variation for the impulses received at O; and accordingly if T denotes the value of E, when $x' = 1$, $p = \frac{2}{3}\frac{\mathrm{T}}{x'^3} = \frac{2}{3}\frac{\mathrm{T}}{\mathrm{V}}$, in which V is the volume occupied by a given number of molecules, N, in terms of the volume, 1,

occupied by the same number of molecules when the distance between their centers is 1.

If now we take account of the attractive impulses answering to the attractive term in equ. (1), it is plain that by a similar investigation we shall obtain for the diminution, d, of the elastic pressure at O, $d=\frac{2}{3}E'$. Accordingly for the actual pressure on an elementary area at O, we have

$$P=\tfrac{2}{3}E-\tfrac{2}{3}E'=\tfrac{2}{3}\frac{T}{V}-\tfrac{2}{3}E'=\tfrac{2}{3}\frac{T}{V}-\tfrac{2}{3}\frac{T'}{f(V)};$$

where T′ denotes the entire energy of the attractive waves that occupy at any instant a hemisphere described around O with the radius 1. It may be shown that unless the number of atmospheres of pressure be great, $f(V)=\text{const.}\,(V)^{\frac{2}{3}}$, approximately. This expression for P is, essentially, the counterpart to the value of p given in the equation of Clausius (p. 441). The first term is directly proportional to the coefficient of repulsion, m, and so to the temperature reckoned from the absolute zero; and inversely proportional to the volume, V, occupied by a given number of ultimate molecules, N. The other term varies from one gas to another proportionally to the coefficient of attraction, n, and varies for the same gas with the volume occupied by the same number of molecules, N; but does not change with the temperature, except as the volume may vary with the temperature, and the value of n also. In view of the result of this investigation it is hardly necessary to add that all the objections which have been urged against the doctrine that the elastic pressure of a gas is due to statical molecular repulsion are entirely inapplicable to the present theory.

For calculating the gaseous pressure in atmospheres I obtain the formula

$$P_{,}=\overset{\text{atmos.}}{1}\times q\left\{1-\frac{kq\left(3+\dfrac{236}{q^{\frac{1}{2}}}\right)}{13{,}924\left(1+\dfrac{q^{\frac{1}{2}}}{118}\right)^{2}\left(1+\dfrac{q^{\frac{1}{2}}}{59}\right)^{2}}\right\}\left(\frac{288\cdot^{\circ}5+t^{\circ}}{288\cdot^{\circ}5}\right)$$

in which $\frac{1}{q}$ = ratio of the volume, in the case of an ideal gas for which $k=0$ and $\frac{m}{x^2}\div\frac{m'}{x'^2}$, answering to the assumed value of u, to the volume at the pressure of one atmosphere, and the mean temperature, 15°·5 C., occupied by the same number of molecules; t° = temperature above the mean taken as a zero point, k = ratio of coefficients of attraction and repulsion, as before, for the gas and temperature considered. The value of k varies with the temperature. We have already seen (p. 439)

that for a certain mixture of oxygen and hydrogen its estimated value is about $2\frac{1}{8}$; and that for carbon-dioxide it is 3·17, when the gas is in the condition and at the temperature referred to on page 438, and increases as the temperature falls, to 4·93 at about the temperature, $-80°$ C. At the critical temperature 30·°9 C., its value is 4·7.

The approximate value of k for any gas at any temperature may be readily obtained, for any other temperature for the same gas, by the empirical law that it is inversely proportional to the $\frac{1}{13}$ power of the absolute temperature. It is to be understood that the calculations are for the value of k at the maximum tension of the gas (vapor) at the temperature considered.

In the liquefaction of oxygen, hydrogen, and nitrogen, when the point of liquefaction, so styled, was reached, the distance, x, between the molecules, must have been reduced to $3·5r$, or very nearly this. This distance answers to the point of ebullition of gases whose molecular curve lies just above the critical curve (for which $k=4·7$). By specific heat ratios we obtain for oxygen, $k=4·93\times\frac{0·9765}{1·96}=2·456$. The reduction of temperature from 15·°5 C. to 145·°5 C. should materially augment this deduced value of k. If we assume that the empirical law holds for oxygen, as for carbonic acid, that k is inversely proportional to the $\frac{1}{13}$ power of the absolute temperature, we obtain $k=2·64$. Now taking $u=3·5$, I find $q=1156·2$. Taking this value of q, and $k=2·64$, the formula gives $P_{,}=272·5$ atmospheres. The volume ratio for the actual gas, for which $k=2·64$, I find to be $\frac{1}{650·9}$. This gives for the density of the condensed gas, 0·881 the maximum density of water; on the hypothesis that the dimensions of the molecules are unaffected by the reduction of temperature. But theoretically this should be attended with a contraction of the effective molecules. If we assume the law of the consequent diminution in the volume of the gas to be the same as that of the increase of k from a fall of temperature, the density comes out 0·94. According to Professor Pictet's experimental determinations the elastic pressure of the condensed oxygen was 273 atmospheres; and the density 0·98.

If we suppose the original value of k (2·456) to remain unchanged and take $u=3·5$, the formula gives $P_{,}=285$ atmospheres; and the density comes out 0·936, and after correction for temperature, 1·00. For $k=2·6$, and $u=3·5$, $P_{,}=277$ atmospheres; and the density is 0·91, or 0·975. For $k=2·63$, and $u=3·5$, $P_{,}=273·6$ atmospheres; and the density is 0·888, or 0·952.

At the point of incipient condensation of carbon-dioxide, just below the "critical temperature" (31° C.), for which $x=7\cdot3r$ I find $q=271\cdot14$. With this value of q, and $k=4\cdot7$ I obtain $P_1=72\cdot2$ atmospheres. Dr. Andrews found the elastic pressure at the critical point to be 75 atmospheres. The small discrepancy results from the fact that the precise critical curve is slightly below that for $k=4\cdot7$, and the corresponding molecular repulsion is greater in the ratio of 51, or 52, to 40. Making the correction, we have for P_1 75 or 76 atmospheres.

These two examples must suffice for the present as illustrations of the applicability of the formula, and verifications of its accuracy.

From the point of view I have taken, chemical combinations consist, essentially, in changes effected in the condition of the molecules of the constituents, by which they are brought into approximate correspondence, and take up the relative positions suited to that uniform condition, just as a mass of similar molecules in that state would do. The change of state consists simply in the nearer approach of the envelopes to the central atoms of the molecules, or in a recess from them, from which results a change in the value of the ratio k, and in the corresponding curve of effective action. The determining cause of this change is the difference in the mechanical condition of the dissimilar molecules, more or less enhanced by the unequal operation of heat or electricity. The immediate result may be either an expansion of the one molecular envelope and collapse of the other, or a collapse of both incited by a flow of electric ether from the source of heat or electricity. The union of chlorine with hydrogen may be cited as a probable instance of the former, and the combustion of hydrogen as an instance of the latter. When metals are oxidized, or solids undergo combustion, we must suppose there is a flow of electric ether from the solid to the oxygen molecule, and the former molecule expands somewhat while the other contracts to the dimensions answering to the solid condition.

Heat, in its association with molecules, consists of the energy of recurring pulses and vibrations in the molecular envelopes, and has two modes of motion or two dynamical aspects, *radial* and *tangential.* The energy connected with the former, is the origin of its expansive force. The propagation of the latter, in ethereal waves of transverse vibration, constitutes the radiant heat emitted by bodies.

Heat energy may be expended not only in the expansion of bodies, but also in augmenting the potential energy of the individual molecules by enlarging their envelopes. In this way a certain amount of heat becomes latent in the process of liquefaction. A portion of the heat of vaporization is expended

in a similar manner. The enlargement of the envelopes here alluded to consists in a recess of the effective envelopes from the central atoms. This should be attended with a certain diminution in the value of r, the distance between the centers of attraction and repulsion posited within the envelopes; and therefore with an increase in the value of $p\left(=\frac{m}{r^2}\right)$. In fact the quantitive determinations I have given, when compared with the results of experiment, indicate that p is materially larger at the same temperature, for liquids and aeriform bodies than for solids. An important tendency of the diminution of the value of r in liquefaction, is to antagonize the expansion directly due to the enlargement of the effective molecules and the attendant diminution in the coefficient n. According as the one or the other of these two tendencies preponderates, the mass will expand, or contract in the act of liquefaction. In the case of any special solid or liquid, the diminution of r with a rise of temperature tends to diminish the expansion, and by increasing p to make the decrement of tenacity less. Any differences in the value of r that may subsist with molecules of different substances, at the same temperature, can only have the effect to alter the positions of the substances on the molecular scale. Any changes or differences that may occur in the value of r, in the case of the gases, will have no effect on the molecular repulsion at those distances, x, for which F, in equ. 1, is sensibly equal to the second term, and therefore, as we have seen, the law of Mariotte holds good; since the repulsion will still be the same for the same actual distance between the molecules. At less distances the tendency should be to alter slightly the deviations from this law.

The value of the coefficient of attraction, n, depends on the excess of the attraction exerted by the central atom of a molecule on its envelope, over the repulsion exerted on it by the condensed luminiferous ether posited between the atom and envelope. The tendency of a recess of the envelope from the atom may be either to diminish, or augment the value of n. It thus may happen that by an increase of n, and a diminution of r, the value of F may be augmented by a certain rise of temperature; as when a bar of wrought iron is heated up to about 400° F. In the case of gases n may change somewhat with the temperature, and in the process of condensation.

The normal type of solidity is a fixed distribution of the ultimate molecules at the angles of successive cubes; and the fundamental principle of the stability of every such elementary cube is that each molecule is in equilibrium, by itself, with each of the others. As the distances are unequal, this implies that k is smaller in the diagonal direction than in the

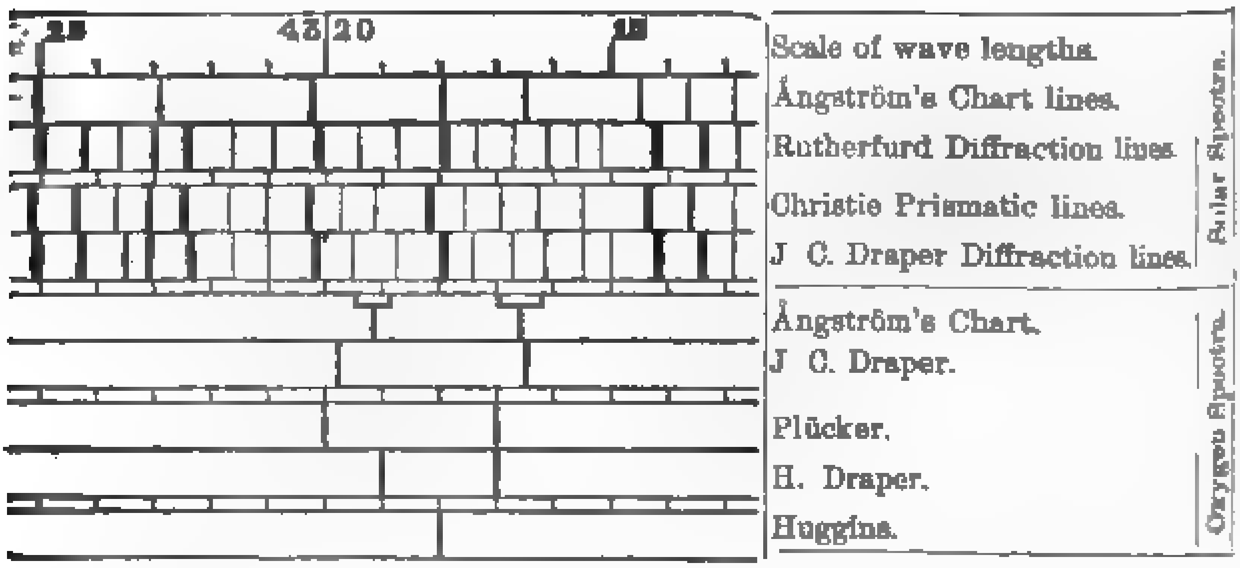
direction of the sides; and thus that the extension, or physical condition of the envelope is unequal in these directions. It is in this sense that "polarity of atoms" (ultimate molecules) exists. Instead of being an inherent property of the atoms, it is liable to change with varying relations to other molecules. When the mass varies in density from one point to another, there is a gradual variation in the size of the elementary cubes, or a gradual transition from cubes to parallelopipedons, or other geometrical figures, with attendant variations in the curves of effective molecular action. The molecular envelopes of different substances may be liable to different varieties of polar condition under the same circumstances, and so the substances may have different types of solidification, or crystallization. For the cubical system I obtain as the complete expression for the elastic resistance to a minute displacement of a single molecule, $f+2f'+1\frac{1}{3}f''$; in which f is the force of resistance developed between the displaced molecule and that lying in the direction of the side of the cube, by a displacement s, in this direction; f' the force of resistance of a molecule lying in the direction of a face diagonal, for the same displacement s, in this direction; and f'' the corresponding resistance of a molecule in the direction of the long diagonal. The value of the expression is the same in whatever direction the displacement occurs. The expression for the lateral force developed, as well as for the elastic resistance to shearing, in the direction of a side of the cube is $f'+1\frac{1}{3}f''$. For any reasonable suppositions that can be made with regard to the comparative values of f, f', and f'', the ratio of these two expressions lies between $\frac{1}{3}$ and $\frac{1}{4}$. The experimental ratios fall between these limits. The resistance to shearing is due to the diagonal forces.

When a body is heated to the point of liquefaction, the values of f' and f'', considered as resistances to tension, which are always less than f, vanish (that is, the curves fall below the axis of x). There is therefore no shearing resistance; which is one of the distinguishing features of a liquid. When the temperature of the liquid is raised above the point of liquefaction, effective repulsions must come into play in the diagonal directions. These repulsions are the operative cause of surface evaporation; and at the same time originate at the surface the "contractile force" which, by the variations it experiences from the contact of solids, is the determining cause of capillary phenomena.

Yale College, Nov. 30th, 1878.

ART. LVII.—*On the Dark Lines of Oxygen in the Solar Spectrum on the less refrangible side of G*; by JOHN CHRISTOPHER DRAPER, M.D., LL.D., Professor of Natural History in the College of the City of New York.

IN a paper on the lines of oxygen, published in this Journal for October, 1878, the solar lines closely coincident with those of the electric spectrum of oxygen were given. The measurements of the solar lines in that instance were taken from photographs made in March, 1878. Since that time, under more favorable atmospheric conditions, I have succeeded in obtaining finer photographs on the less refrangible side of G. These show many faint lines, not visible in the photographs of March 1878, while many other lines are distinctly sub-divided. Three of the recent photographs were taken on the same day, during the last week in November, and two have been taken since that time; one during the last week in January, and one during the first week in February. In all five of these photographs faint lines are visible between λ 4816 and λ 4320, of Ångström's scale, and they all show them in the position indicated by the diagram and table. The fact that all the photographs agree in their representation of these lines, is, I think, proof positive of the correctness of the positions assigned.



To place the question of the oxygen lines in this region as clearly as possible before the reader, I have devised a diagram which represents the facts regarding this portion of the solar spectrum, together with the wave lengths of the oxygen lines obtained from the electric discharge in air, and in oxygen gas. The final drawing of the diagram was made for me by my assistant, Mr Sickels, from the wave lengths given in the table at the close of this article. The drawing was on the scale of one centimeter to each wave length. This was photographed

down to one-half its size by a photo-engraving operation. From the plate so produced, the diagram was printed. For accurate work the figures in the tables should be employed.

The first space of the diagram beneath the scale of wave lengths gives the positions of the solar lines of Ångström's chart.

The second represents measurements made from one of Dr. Rutherfurd's paper prints of this region. These measurements were made after I received Mr. Christie's paper, with a view to the detection of any difference between Dr. Rutherfurd's photograph and my own.

The third space contains a presentation of the lines of this region as given by Mr. W. H. M. Christie, of the Royal Observatory at Greenwich, in the Monthly Notices of June, 1878. This I did not receive until the latter part of last January, when I was much pleased to find the close coincidences of our results, although they were obtained by entirely different methods, and without any knowledge of each other's work. Line by line Mr. Christie's map is the counterpart of the spectrum I had mapped from the photographs taken during the last week in November, and since that time. Not only do these maps agree very closely in the placing of the lines, but the similarity in intensity is also marked. The presence of these faint lines in Mr. Christie's prismatic spectrum settles any objection that might be raised on the ground of their being interference lines in the diffraction spectrum.

The fourth space presents the measurements of my recently taken photographs. The accuracy of adjustment to Ångström's scale is shown by the coincidences in the lines λ 4312·8 and λ 4325·2. The comparison of this with my reading of Dr. Rutherfurd's photograph, as given above, while it shows slight differences, is a very satisfactory evidence of the reliability of the photographic method of investigating this problem. It is also a refutation of the objections raised by some to my system of measuring and studying the lines of the solar and other spectra. Indeed, with proper lenses, and in competent hands, the process I have followed is not only very reliable, but the apparatus may be truly regarded as an instrument of precision. Of these I hope to give ample proof hereafter.

The position of the lines in this region of the solar spectrum being established by three independent observers, and the question of primary importance, as Mr. Christie justly calls it, settled; we pass to the examination of what these lines probably represent. First: Oxygen. Beneath the four charts of the solar spectrum, I have placed five sets of measurements of the oxygen lines in the vicinity of G. Beginning below, Huggins gives a single line at λ 4318. The other observers all

divide this, H. Draper places the two branches at λ 4317 and λ 4319; Plücker at λ 4317 and λ 4320. My own readings are at λ 4316·50 and λ 4319·75. Those of Ångström's chart are at λ 4316·57 and λ 4319·15.

In the above measurements, those for the more refrangible line are all within one-half of a wave length. The readings of the other line are within one wave length. In these positions there are, therefore, oxygen lines, and in the same regions of the solar spectrum, Dr. Rutherfurd, Mr. Christie, and myself, agree in finding faint dark lines. More than this; granting that the forked symbols of Ångström's chart indicate, (and I cannot understand what else they mean) that the observer believed that the line λ 4316·57 is divisible into two lines, placed at λ 4316·20 and λ 4316·95, and the line λ 4319·15, into two, placed at λ 4318·85 and λ 4319·45, we find that the three charts of the solar spectrum gives lines which are very nearly coincident with the readings of these forked symbols. It is not often that the results obtained by so many independent investigators agree as closely regarding a problem to be solved only by observation and experiment, and considering the smallness of a wave length, and the difficulty of making such measurements, the agreements must be regarded as favoring strongly the identity of these feeble lines of the solar spectrum with the lines of the electric spectrum of oxygen.

Among the obstacles in the way of comparing the electric lines of oxygen with those of the solar spectrum, and which in part explains the discrepancies that exist in the measurements of the lines of oxygen, is the difficulty in making exact measurements of these lines. Of this difficulty Plücker speaks in a memoir on the oxygen spectrum in the Phil. Trans. for 1865. In the same memoir he also discusses the variation in the breadth of the lines, and the variation in this variation, in different parts of the electric spectrum of oxygen. The positions given by Plücker and myself agree closely, although he gives no fractions. We both used two prisms of flint-glass, though at times he used four. Plücker's results, and my own, were obtained in pure oxygen gas, while those of H. Draper, and of Ångström's chart, were from the electric spark in air. This may possibly explain why they agree in differing slightly from Plücker and myself.

In the measurement of the lines of the solar spectrum made by Mr. Christie, the spectroscope was, he says, equal in dispersion to fifteen prisms of 60°. Dr. Rutherfurd's photographs and mine were made by means of Rutherfurd's gratings of over 17,000 lines to the inch, mine being by reflection and in the second order. The great dispersion thus brought to bear upon the solar spectrum, is, I think, the explanation of the sub-

division in that spectrum, of the electric oxygen lines given as two, by Plücker, H. Draper and myself. I do not know what the dispersion power was, nor the exact electric conditions that gave the forked symbols of oxygen in Ångström's chart; but whatever the dispersion, and whatever the electric, and consequent thermal or other condition, they seemed to have produced results very close in their relation to those in recent photographs of the solar spectrum.

Discussing the existence of bright lines of oxygen in the solar spectrum at λ 4317 and λ 4319, Mr. Christie directs attention to the opposing fact, that the spaces at λ 4315 and 4321·5 on Dr. Rutherfurd's photograph are both brighter than those at λ 4317 and λ 4319. This is also shown by my photographs, in which the slit was sufficiently narrow. I may add, that there are in my photographs, and in that of Dr. Rutherfurd, in the region from 4290 to 4301, many lines brighter than any in the spaces mentioned. Accepting these as being the true measures of brilliancy of the bright background of the spectrum in this region—and there is no reason why we should not do so—we are justified in saying, that from λ 4314 to λ 4322, and particularly in the vicinity of λ 4317 and λ 4319, there is something in the solar envelopes, which by absorption, reduces the brilliancy of the spectrum. In addition there are also faint lines which occupy the positions of certain electric oxygen lines.

If these faint dark lines are not the result of the action of oxygen, to what other cause are they to be attributed? Besides the well marked lines of calcium and titanium, no one places lines of any element here except Huggins, who claims a weak strontian line at λ 4319, and a carbon line as given at λ 4320, in Watts' Index. The space from λ 4315 to λ 4318 is free from any claimant, and here there are lines, representing the position of the line of oxygen, upon which nearly all the measurements closely agree. It appears to me that this want of any other explanation, is a fact of importance by no means to be overlooked, in arriving at the true solution of the problem of the oxygen lines.

In the table, the wave lengths of all the lines of the solar spectrum in this region are given, according to Ångström's scale. In Dr. Rutherfurd's photograph, I think, several of the lines are subdivided, according to the figures presented in the last column. An inspection of the original photograph of the spectrum itself is required to decide this matter, as the enlarged paper print in my possession is not entirely satisfactory, giving only the appearance of subdivision as I have recorded.

Conclusions.—1st. The regions in the solar spectrum at λ 4317 and λ 4319 claimed as bright lines of oxygen, are not as bright as others in their immediate vicinity.

2d. The solar spectrum shows faint dark lines in the region about λ 4317 and λ 4319.

3d. Oxygen is the substance which can produce dark lines in this region, therefore we must attribute them to the presence and action of that element.

Ångström's Chart Elements.	Solar Spectra.				Oxygen Electric Spectra.					Additional Subdivisions. Rutherfurd's Photograph.
	Ångström Chart.	Rutherfurd.	Christie.	J. C. Draper.	Air. Ångström.	Oxygen. J. C. Draper.	Oxygen. Plücker.	Air. H. Draper.	Huggins.	
	4312·85	4312·8^{4}	4312·85^{1}	4312·85^{4}						
Ti	13·67	13·4^{9}	13·60^{7}	13·40^{9}						
Fe	14·50	14·2^{10}	14·35^{9}	14·20^{10}						14·0^{4} 14·2^{5}
		15·2^{1}		15·00^{0}						
		15·6^{0}	15·50^{1}	15·45^{0}						
		16·1^{3}	16·25^{3}	16·15^{3}	16·20					16·0^{3} 16·2^{4}
	16·50	16·7^{1}	16·90^{6}	16·72^{1}	16·95	16·60^{8}	17·00^{6}	17·00^{6}		16·5^{1} 16·9^{6}
		17·3^{1}	17·55^{1}	17·40^{1}						
Ca	17·96	17·9^{9}	18·15^{6}	17·95^{9}					18·00^{6}	17·8^{1} 18·0^{3}
		18·7^{2}	19·10^{1}	18·75^{2}	18·85			19·00^{6}		
		19·4^{1}	19·70^{1}	19·50^{0}	19·45	19·75^{6}	20·00^{5}			19·2^{1} 19·6^{1}
Ti	30·25	20·1^{8}	20·25^{6}	20·13^{8}						20·0^{4} 20·2^{4}
		20·9^{4}	21·03^{4}	21·00^{3}						20·8^{4} 21·0^{1}
		21·6^{1}	21·70^{0}	21·65^{0}						
		22·4^{2}	22·50^{8}	22·23^{9}						22·3^{7} 22·6^{5}
Ti	22·90	23·0^{7}	23·10^{7}	23·10^{8}						
		23·6^{4}	23·70^{5}	23·50^{6}						
		24·2^{7}	24·40^{9}	24·25^{9}						
Fe	25·05	25·0^{10}	25·18^{9}	25·03^{10}						24·8^{9} 25·2^{9}

The value 0 is given to exceedingly faint lines.

ART. LVIII.—*On the Genesis of Cinnabar Deposits;**
by S. B. CHRISTY, Ph.B.

THE study of the origin of mineral veins has developed no fact more clearly than the great importance as a transforming agent of solutions of the alkaline sulphides and carbonates. A constantly increasing number of geological phenomena are being explained by their influence, and the importance which was given to the sublimation theories by the older geologists is gradually diminishing.

The ores of mercury, however, partly from the fact that they have been but little studied, and partly from the ease with which they are volatilized, together with the difficulty of accounting for their solution in any of the reagents which exist in nature, have generally been regarded as formed by sublimation. Even in so recent a work as that of M. H. Kuss, (Mémoire sur les Mines et Usines d' Almaden, reprint from Annales des Mines, p. 47), the author says: "We should always recognize in cinnabar the character of a vein substance carried to the surface very probably in a state of vapor."

The purpose of the present paper is a discussion of the two theories as to the formation of cinnabar deposits. We shall endeavor to find an answer to the question, "Are cinnabar deposits produced by sublimation, or are they deposited from solution?" In considering this question, it will be necessary to briefly review the facts to be explained, and the present state of knowledge of certain of the compounds of mercury. The subject will therefore be divided as follows:

First. The facts to be explained—a brief synopsis of the nature of some of the more important cinnabar deposits.

Second. Some of the more important properties of cinnabar.

Third. The results of some original investigations upon this subject.

Fourth. A comparison of the relative probabilities of the two theories.

FIRST.—THE CHARACTERISTICS OF SOME OF THE MORE IMPORTANT CINNABAR DEPOSITS.

I begin with the deposit with which I am personally acquainted, that of New Almaden. This has already been well described by Professor Silliman in this Journal, but a statement of its principal points may not be out of place.

The New Almaden quicksilver mine is situated about thirteen miles southwest of San Jose, California, in a low range of

* A paper read before the Geological Section of the California Academy of Sciences, Dec. 14, 1878.

hills. This range begins at the Hacienda Creek and runs parallel to the Coast range for about four miles, where it is cut by the Guadelupe Creek. These hills, so far as exploited, are composed of serpentines overlaid by magnesian schists which are nearly always black. On analysis they were found to contain, besides silicate of magnesia, a great deal of iron and considerable alumina. Overlying these are other schists, which become more and more aluminous, until finally they change into clay slates. These latter rocks are everywhere greatly metamorphosed, in some cases so much so, that they approach the darker ferruginous varieties of jasper both in appearance and hardness. All of these overlying schists have the same general dip as the surface of the hills themselves, modified of course more or less by subsequent erosion. The serpentine gave as the result of qualitative analysis, large amounts of magnesia and silica, with smaller amounts of iron and alumina, and traces of chromium, manganese, calcium and nickel.

Lying between these magnesian schists, to which the Mexican miners have given the name "Alta," and the Cornishmen "Hanging Wall," and the serpentine beneath is found the deposit of cinnabar. The "vein matter" itself appears to be a serpentine somewhat altered by infiltrated waters. It is sometimes extremely hard and tough and difficult to mine; at other times it is soft and fragile. A qualitative analysis of a specimen of the former kind selected by the mining captain as the hardest rock in the mine proved it to contain besides the cinnabar, the same ingredients as the serpentine itself, viz: hydrated silicate of magnesium, with small amounts of iron, chromium, calcium and nickel.

Associated with the cinnabar are found dolomitic crystals of pearl spar, iron pyrites, chlorite, and extremely seldom crystals of quartz. Another notable fact is the occurrence of a bituminous substance resembling idrialite. This substance is wrongly stated by Mr. Kuss, in the memoir above cited, to be "a veritable coal." It is not a true coal. It sometimes has the external appearance of a soft bituminous coal, but when heated melts and flows like bitumen. Ordinarily it is found in the liquid condition, and flows from the drusal cavities in which it is contained when they are opened. When strongly heated it gives off highly inflammable hydro-carbon vapors, and leaves an intumescent coke which is very light and fragile, and burns with scarcely any ash. Sometimes the schists spoken of are impregnated with a hydro-carbon more like petroleum, as in the 1,500 and 1,600 feet levels of the Randol shaft.

In that part of the mine known as the Cora Blanca, there is a sheet of dolomitic limestone which extends from the top to the bottom of the mine. This lies immediately beneath the Alta

in most cases, although some ore has been found above it. It varies in thickness from one to two feet. In analyzing this there was found a very small residue insoluble in the hydrochloric acid, which under the microscope proved to contain fragments of iron pyrites. (The substance had been powdered.)

In the various workings there occurs sandstone, particularly in the Cora Blanca. The sandstones seem always to overlie the "vein matter," though in the latter mine they are sometimes impregnated with cinnabar, and are said to have contained when first opened, some native mercury. The exact position and significance of these latter rocks I have not as yet been able to determine. It is altogether probable, however, that they are more or less local in their origin, being the result of slightly varying conditions which existed during their deposition. Such a supposition would account for the gradual change of the sandstones into slates, which often takes place in such a manner as to make it difficult to determine to which class to assign them.

Native mercury occurs rarely; chiefly in the sandstones of the Cora Blanca, but also in the 1,500 and 1,600 feet levels of the Randol shaft, where it ran out of the shattered Alta upon opening out the vein-matter at places where it was much broken up by faulting.

In many cases the micro-crystals of cinnabar are most intimately mixed with those of dolomite, and occasionally with those of quartz. The cinnabar even when apparently pure to the eye, is so thoroughly impregnated with bitumen that a lump of it when distilled out of contact with the air leaves a carbonaceous residue.

Throughout this interesting mine there are many evidences both of chemical and of mechanical action.

A strongly alkaline spring with free carbonic acid (the New Almaden Vichy spring) is still active at the Hacienda. Occasionally springs with sulphydric as well as carbonic acid are opened by the drifts. In the mine "slickenslides," or surfaces polished as smooth as glass by slipping on each other, are frequently met with; and often large masses of serpentine are broken off bodily and are buried in the superincumbent mass of Alta.

The ore is very irregularly distributed throughout the vein-matter, frequently disappears altogether and reappears in such an uncertain manner that, despite the well established course of the ore body, or rather of the "alta" or "hanging wall," there is required a great deal of skill and judgment for the proper exploitation of the mine.

The Gaudelupe and the now abandoned Enriquita mines

appear to belong to the same formation; but it would require a thorough examination of all of this series of mines to trace out this and other interesting questions. I have dwelt thus long upon some of the characteristics of this mine because it is in many respects typical.*

Von Cotta in his *Erz-lager Stätte*, vol. ii, p. 616, gives the following as the characteristics of the principal cinnabar mines of Rhenish Bavaria, Bohemia, Alps, Upper Italy and Spain:

Country Rocks:—Sandstone, clay-schists, trachyte, talcose mica slate, limestone and quartzose mica slate.

Ore matter.—Cinnabar, blende, galena, tetrahedrite, limonite, amalgam, copper pyrites, iron pyrites, silver ores, native quicksilver, horn quicksilver, idrialite, lebererz, magnetic iron pyrites.

Vein filling.—Quartz, hornstone, heavy spar, calc spar, dolomite, spathic iron, gypsum.†

Such a general distribution of carbonates certainly argues against the sublimation hypothesis. With a few exceptions these cinnabar deposits are not in *immediate* relation to igneous rocks, but are nearly always found in metamorphic rocks. In some cases, seven out of sixteen, Von Cotta describes these deposits as veins, the others as in clefts (*klüfte*), layers or impregnations. Usually, with the notable exception of Almaden in Spain, cinnabar does not seem to occur in true fissure veins, but rather to be interspersed in the ore body in a very irregular manner, as is indicated by the term "impregnation."

SECOND.—THE CHEMICAL PROPERTIES OF SOME OF THE SALTS OF MERCURY.

The inquiry here becomes at once limited within very narrow boundaries.

The stable salts of mercury which could exist in any natural mineral waters are very few. The mercuric chloride is at first sight the most probable one, the sulphate not existing in solution except in the presence of a free acid. Still, salts of mercury have been proved to exist in at least one mineral water. In the analysis of the spring "du Rocher,"‡ there is given as a constituent of the water a small amount of mercury. It was very small; the total amount of all the heavy metals, including mercury, estimated together was only 0·008 grams per liter. But the author states that he obtained enough mercury from 500 liters to exhibit it in the metallic state.

* For another description of this and other deposits in California, etc., with other interesting facts, see "Les Gisements de Mercure de Californie," par M. G. Rolland," Annales des Mines, 1878, and also "Bulletin de la Société Minéralogique de France, 1878; Bull. No. 6."

† For a full description of the deposits of Almaden in Spain, see the article of Mr. Kuss above cited, pp. 10–49, or translation by the writer, pp. 6–19–20.

‡ St. Nectaire-le-haut, Puy-de-Dome, by M. Garigon, Comptes Rendus, vol. xxxiv, p. 936.

It seems much more probable, however, that the salt of mercury usually regarded as the most insoluble is the one in which we are directly interested, i. e. the mercuric sulphide. This salt, while insoluble in almost everything else, is well known to be soluble in solutions of the alkaline sulphides containing free alkali. This fact is recognized both by Rose and Fresenius, but I have been unable to find any exact statements as to the degree of solubility. Prof. V. Stein, in Dingler's Polytechnisches Journal, vol. cxxxviii, p. 390, states: "I found that sulphydrate of sodium as well as potassium dissolved cinnabar even in the cold with the same ease as water dissolves sugar." This statement is, to say the least, a great exaggeration. He also states that the polysulphides of the alkalies failed to dissolve any noticeable trace of the sulphide of mercury. Fresenius* finds that yellow sulphides of ammonium dissolve traces of sulphide, of mercury, particularly in the cold. Barfoed† states that while sulphides of sodium and potassium dissolve mercuric sulphide sulphydrates of the alkalies, as well as sulphydrates to which sulphur has been added, fail to do so.

On the other hand, Dr. R. Weber‡ states that he found that sulphide of potash dissolves the mercuric sulphide only in the presence of free potash or soda. Moreover, that the addition of carbonic acid, sulphydric acid, or flowers of sulphur, precipitates the mercury from such a solution completely.

Again it is well known that the polysulphides of the alkalies change the black variety into cinnabar, which could hardly be the case unless partial solution had taken place. Also, that when mercuric sulphide is slowly deposited from such solutions cinnabar results, but when rapidly deposited as by dilution, etc., the black or amorphous modification; finally, that cinnabar volatilizes out of contact with the air at a little below red heat, depositing cinnabar when slowly cooled, and the amorphous variety when rapidly cooled.

Such in brief is at present the not altogether satisfactory state of knowledge on this subject.

THIRD.—EXPERIMENTS UPON THE SOLUBILITY OF MERCURIC SULPHIDE IN SOLUTIONS OF THE ALKALINE SULPHIDES AT HIGH TEMPERATURES AND PRESSURES.

The great difficulty of accounting for the deposits of cinnabar in the wet way has always been the difficulty of finding any natural solvent for this substance. The experiments of Weber, cited above, show that as soon as the free alkali is neutralized either by carbonic or sulphydric acid the mercuric sulphide is precipitated completely from its solution in the alka-

* Zeitschrift für analytische Chemie, vol. iii, p. 140.
† Journal für praktische Chemie, vol. xciii, p. 244.
‡ Poggendorff's Ann. d. Phys. u. Chem., vol. xcvii, p. 76.

line sulphides; and, as free alkali is not known to exist in any natural mineral waters, the question has still remained, "In what has this substance been dissolved, if we are to suppose it to have been formed in the wet way?"

The classic researches of Daubrée on metamorphism,* and those of De Sénarmont† on the formation of mineral veins in the wet way, as well as the fact that these solutions must have originally acted at higher pressures and temperatures than those of the atmospheric waters, led to the following investigations.

Impressed with the idea that moderate increase of temperature and pressure might possibly bring about the desired results, I was led to adopt a more easily manageable apparatus than that used by the investigators already mentioned.

For this purpose I used a Papin's digester of gun metal, about 7¾ inches high, 3¼ inches in outer diameter, and $\frac{4}{16}$ inch thick. This vessel was calculated to stand with safety a pressure of 650 to 700 lbs. per square inch. It was provided with a safety-valve so that the pressure could be easily regulated at any point, and as an additional check it was heated in a bath of iron filings, so that the temperature could be approximately determined. The whole was surrounded by a sheet-iron shell to guard against the danger of explosion. The digester was heated by an ordinary Bunsen burner. The substances to be experimented upon were enclosed in glass tubes usually sealed at both ends, but occasionally open at the top so as to allow the contents to slowly evaporate under pressure, after the water in the digester itself had evaporated through the safety valve.

The only disadvantage of using this form of apparatus was the difficulty of determining when the water was entirely evaporated. This led to several explosions of the sealed tubes within the digester and the consequent loss of many days' work. The joints were all made with a lead packing, as paper, leather, etc., would not resist the high temperatures at which the experiments were conducted. The highest temperatures reached were in the neighborhood of 250° C. (482° F.). The thermometer at the bottom of the bath of iron filings indicated 360° C. and at the top 150° to 200° C.

The first experiment made was with a tube containing amorphous mercuric sulphides with a solution of potassic sulphydrate (potash solution saturated with sulphydric acid.) The tube was open at the top and its contents were allowed to evaporate to half their bulk (after the water in the digester was evaporated) under a pressure of 150 lbs. per square inch. The temperature was about 180° C. The operation was continued five hours. The sulphide was entirely changed to a red pow-

* Ann. des Mines, 5 Serie, vol. xvi, p. 155 and 393.
† Ann. de Chem. et Phys., vol. xxxii, p. 129.

der and the next day the tube was found to contain a beautiful coherent mass of crystals of cinnabar, recognizable by the naked eye, simulating the crystals which occur in nature very perfectly. They appeared to be rhombohedrons, although I have not been able to determine this with certainty.

Subsequently a large number of experiments were made, all with closed tubes, upon various solutions in contact with amorphous mercuric sulphide, for the purpose of determining the action of these different reagents. The temperatures varied from about 200° to about 250° C., and the pressures from 260 to 500 lbs. per square inch. The determinations of the pressures were not perfectly exact, owing to the difficulty of making the valve-seat bear with perfect uniformity. The duration of the heating varied in the different experiments from three to ten hours, and in each case the digester with its contents was allowed to cool undisturbed till morning.

The results of these experiments are as follows:

Solutions of sodium bicarbonate did not change the amorphous variety of mercuric sulphide to cinnabar. Solutions of water-glass were equally powerless. But when through either of these solutions sulphydric acid was passed, and the tubes were again heated in the digester, the transformation was complete. Polysulphide of potassium as well as sulphydrate changed the amorphous sulphide very rapidly and completely. The presence of excess of carbonic acid seemed to retard the formation without being able to prevent it. The cinnabar formed was usually in the state of micro-crystals, like vermillion, but often they were larger and more like the native cinnabar in appearance, though they were so minute as to make the determination of the crystalline form extremely difficult. In all cases when the transformation had taken place, the liquid would stain the skin deep black, as is usual when mercuric sulphide is dissolved in alkaline sulphides. This would be an additional proof, if one were needed, that solution had taken place.

Finally, I was led to try the effect of heating the amorphous sulphide with the New Almaden Vichy water, to which sulphydric acid had been added. This water as analyzed by E. Piquet, Mining and Scientific Press, vol. xviii, p. 360, has the following composition:

"Bicarbonate of soda	50·3	grains.
Bicarbonate of lime	8·0	"
Sulphate of lime	10·5	"
Sulphate of magnesia	3·0	"
Chloride of sodium	8·4	"
Oxide of iron	1·2	"
Silica	traces."	
Carbonic acid	28·2	"

This amount was contained in a bottle of two pounds.

Sulphydric acid was passed into this water for half an hour, an equal amount of mineral water, and some black mercuric sulphide were added to it, and the mixture was treated in the digester, while a similar experiment was carried on at the ordinary pressure of the atmosphere and a temperature of 100° C. The temperature of the digester was not more than 180° C., and the pressure 140 to 150 lbs. The time in both cases was two hours. The sulphide which was treated in the open air was unchanged even when examined with the microscope, while that treated in the digester was brownish red even to the naked eye, while under the microscope it showed itself to be composed of a small amount of as yet unchanged amorphous sulphide, and a larger amount that was completely transformed to cinnabar. Crystals were not visible with the powers used.

This mineral water, therefore, when the single ingredient of sulphydric acid is added to it is capable of dissolving mercuric sulphide, and of depositing it from solution in the crystalline form when it is slowly cooled.

Fourth.—The Rival Theories.

It would be idle to attempt to follow the mercuric compounds from their existence in the nebulous mists to the ore deposits in which they are found to-day, but it is altogether probable, from the great permanence of the mercuric sulphide, that the mercury salts would be precipitated in that form soon after the waters had been deposited, and that the mercury would be found in that as sulphide in the earliest sedimentary deposits. On the one hand we have the sublimation hypothesis to account for the present position of these ore deposits, and on the other the solution theory. Now, while it is probable *à priori* that as these deposits were buried deeper and deeper by subsequent debris, that the interior heat of the earth would raise them to such a temperature that *if sufficiently extensive fissures were to occur volatilization might ensue*, and the vapors would rise upward to such points as would permit their recondensation; and while it is possible that in special cases as in the vicinity of eruptions of true igneous rocks such may be the case, at the same time *it is probable that the deposits as they exist to-day in situ are the result of the action of mineral waters, which act either by leaching out the cinnabar from neighboring rocks, or more probably by bringing it from lower rocks.*

In support of this position are the following facts: In the first place, cinnabar volatilizes only at just below a red heat (500° C.), when exposed to the ordinary pressure of the atmosphere. Now, if we take the increase of temperature as 1° C. for each 100 feet below the surface, it would take a depth of nearly

50,000 feet to give this temperature. At New Almaden, for example, which is certainly not in the immediate vicinity of volcanic rocks, since the cinnabar outcrops upon the summit of the hills, we should have to assume an erosion to have taken place of nearly nine and a half miles of strata. The age of the formation (pronounced Cretaceous by Prof. J. D. Whitney, in the Geological Survey of California), hardly admits of such an hypothesis. On the other hand it is impossible that the foldings, etc., due to mechanical action, occurring as they usually do so gradually, could have given rise to the necessary temperature. And even assuming that at the time of the formation there was a rate of increase of temperature with depth three times as great as at present, it would still require a depth below the surface of three miles to give such a temperature.

Not only so, but at such a depth the enormous pressure of superincumbent strata would greatly increase the heat necessary for sublimation. This fact is well illustrated by the case of water. The natural rate of increase of temperature due to internal heat can never be great enough to convert water into steam except by the presence of local igneous rocks. Pfaff, in his Geologie als Exacte Wissenschaft, p. 112, shows this by the following table.

Depth in feet.	Temperature. Centigrade.	Pressure of water in atmospheres.	Tension of steam in atmospheres.
10,000	100	300	1·
20,000	200	600	15·3
80,000	800	2400	1416·
100,000	1000	3000	1877·
200,000	2000	6000	2403·

The third column gives the weight in atmospheres of a column of water of a height equal to the depth; this is the minimum pressure to which it can be exposed, unless we suppose an extensive fissure filled only with air and extending far upward. The fourth column gives the tension of steam at the temperatures corresponding to the depths calculated according to Regnault's formula. It is evident that under these conditions the water will never boil at any depth except in cases of local eruptions of volcanic rocks. Although there have not been, to my knowledge, any determinations of the elastic force of cinnabar vapor, it is probably less than that of steam, and the above reasoning will apply with even greater force to this case.

In the second place, the deposits themselves, as indicated in our study of the principal cinnabar deposits, do not usually show the signs of true fissure veins, but are rather found irregularly disseminated in layers and impregnations; nor are volcanic rocks usually found in sufficient proximity to give the heat necessary for volatilization.

In the third place, the formation of many of the ore bodies cannot be explained upon the sublimation hypothesis. Many of them, notably that of New Almaden, contain carbonates so intimately mixed with cinnabar that the conclusion is inevitable that they were formed in the same, i. e. in the wet way. The occurrence of quartz and bitumen intimately mixed shows the same thing.

Again M. Kuss* himself, though evidently inclined toward the volatilization theory, admits that: "The material of the quartzite which is lacking to-day in the rocks impregnated with cinnabar, certainly could not have been missing either at the time of the first deposit of the beds or after the strong pressure which compressed and straightened them. How could this disappearance of siliceous matter be effected, matter almost inattackable by all the reagents which we can imagine to have intervened during the epoch of the formation of the veins of cinnabar?" This disappearance of siliceous matter is certainly inexplicable by the sublimation hypothesis; but by the supposition that the cinnabar was deposited from solution in a mixture of alkaline sulphides and carbonates, it is not only explained but also would be a perfectly natural consequence of the main supposition.

Still again, of the minerals which were mentioned in the first part of the paper as accompanying cinnabar, all, with the possible exception of magnetic iron pyrites, have been produced in the *wet way* by various experimenters as the following references will show.

Blende, by De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Galena, by De Sénarmont, Ann. Ch. Phys., xxx, 139.
Fahlore minerals, by De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Iron pyrites, by De Sénarmont, Ann. Ch. Phys., xxx, 140.
Horn quicksilver, in many ways.
Quartz, { Daubrée, ibid.
De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Heavy spar, De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Dolomite, Hunt, Am. Jour. Science, II, xxviii, 170, 365; xlii, 49.
Spathic iron, De Sénarmont, Ann. Ch. Phys., xxx, 153.
Gypsum, Hunt, Compt. Rend., xlviii, 1003.
Calc spar, { Becquerel, Compt. Rend., xxxiv, 29, xxxvi, 207.
Rose, Pogg. Ann., xii, 533.

The production of bituminous material similar to idrialite has been accomplished in the same way, by heating organic matter with water in closed tubes at high temperatures.† In fact this transformation is invariably regarded not as the result

* Memoire sur les Mines et Usines d'Almaden, p. 44. Translation of same by writer, p. 21.

† Daubrée, Metamorphism, Annales des Mines, 5th series, vol. xvi, II, end of chap. iv.

of *dry distillation*, but as the effect of heat in the presence of water. And if the temperature were great enough to have volatilized cinnabar, it is probable that these much more volatile hydrocarbons of the original organic matter would have disappeared, and we should have anthracite or graphite instead of bitumen, as we do in most of the cinnabar deposits.

In addition to this we have shown that the sulphide of mercury at comparatively moderate temperatures is soluble in solutions of the alkaline sulphides, *that increase of pressure aids rather than retards this solution*, and that cinnabar is deposited from such solutions in the crystallized form when the temperature and pressure are slowly lowered. We have shown that by adding sulphydric acid to the mineral spring water, now existing in the neighborhood of one of the most noted of these deposits, we were enabled to produce the same effects. For various reasons, which it is unnecessary to state here, it is probable that this spring once contained sulphydric as well as carbonic acid, and we have, consequently, in the case of the New Almaden mine, sufficient cause at least for the deposit without invoking the sublimation theory.

Again, the occasional occurrence of metacinnabarite is easily explainable by the sudden dilution of the depositing waters by waters of other springs, by water from above, or by the local mixing during the crystallization process with carbonic or other acid gases. Such a mixture of amorphous sulphide with minute crystals of cinnabar, as described by Moore, (Ueber das Vorkommen des amorphen Quecksilbersulfids in der Natur) is easily reproduced by any of these methods. No other theory so well accounts for the intimate mixture of the two varieties; for the amorphous product produced by suddenly cooling the vapor presents an entirely different appearance.

Finally, the almost universal occurrence of these deposits in metamorphic rather than in igneous rocks, accords well with the theory that *these deposits as they exist in situ are the immediate result of the action of solutions of alkaline carbonates containing also alkaline sulphides.*

There are still many other points of interest in this connection which are difficult to understand. Such, for example, are the wide spread association of serpentine and other magnesian rocks, and of the bituminous substance idrialite with cinnabar. It is possible that these are conditions as well as mere concomitants. Lastly, there remains the occurrence of native mercury to be explained. Unless we regard it as the effect of the local oxidation of a very stable compound, its appearance is well nigh inexplicable upon either hypothesis.

University of California, Berkeley, Dec., 1878.

ART. LIX.—*Notice of Recent Scientific Publications in Brazil.—O. A. Derby on the Geology of the Lower Amazonas;* by RICHARD RATHBUN.

THE Archivos of the National Museum of Rio de Janeiro, which were started in 1876, and of which only a single volume was published regularly, have again made their appearance. The numbers recently received, and issued only in the early part of this year, comprise volume II complete, for 1877, and the first half of volume III, for 1878. They are accompanied by numerous plates, some of which seem to have been carefully executed. The cause of the delay in the publication of this annual, the only one devoted to natural history memoirs in Brazil, is not given, but the high character of several of the articles contained in the present volumes, partially compensates for their late issue.

Dr. Fritz Müller, of Santa Catharina, contributes to both volumes interesting papers on certain structural points among insects, principally on the scent-bearing organs of several species of Lepidoptera, and, in volume II, treats of the correlation of the versicolored flowers of a species of *Latana*, of Santa Catharina, and the insects which fertilize them. Dr. Lacerda, of the Museum, gives the results of his experiments with the poison of *Bothrops jararaca* and *Bufo ictericus* on several domestic animals. The second volume also contains "Notes on the Localities of Antiquities (Ceramios) of Pará," by S. Ferreira Penna, and an extended memoir, entitled "Notes on the Stone Lip-ornaments of the Archæological Collection of the National Museum," by Dr. Ladislau Netto, the director of that institution. In the third volume are two short geological and mineralogical studies of small sections in the province of Minas Geraes, by members of the School of Mines of Ouro Preto.

The paper of greatest interest to North Americans, however, is "A Contribution to the Geology of the Lower Amazonas,"* by Mr. Orville A. Derby, formerly of the Geological Commission of Brazil, but recently appointed geologist in the National Museum at Rio de Janeiro. This memoir, which occupies considerable space in volume II, is a résumé of the principal results of the explorations of the late Prof. Ch. Fred. Hartt, Mr. Derby and others, in the Amazonian valley, and adds many important facts and generalizations to those hitherto published.

The first portion of the paper is devoted to a discussion of the topography and hydrography of the basin of the Amazonas, and of the relations of the great river and its many large tributaries

* The English version of this paper was published in the Proceedings of the American Philosophical Society of Philadelphia, for February, 1879.

to the surrounding table-lands and mountain chains, which direct their courses. Mr. Derby endeavors to show that between the three sections of the Rio Amazonas, popularly called the Marañon, Solimões and Baixo Amazonas, or upper, median and lower courses, there exist not only topographical differences, but also very marked differences in geological structure. After briefly describing the general geological history of the Amazonian region, as brought out by Prof. Hartt, the author enters into a detailed account of the several formations, that have been discovered in the lower valley, the immediate subject of his article. The most important conclusions recorded by him are the following:

The metamorphic deposits composing the plateau and mountain range between Guayana and Brazil, and the central Brazilian plateau, and thus bordering the Lower Amazonian basin on the north, and forming its higher lands on the south, may be divided into two series—a lower one, consisting of highly crystalline rocks, and an upper one, of generally non-crystalline rocks. The former, which constitutes the most of the Guayanian plateau, and forms the base of that of Brazil, consists of gneiss, gneiss-granite and syenite, and has been referred by Prof. Hartt to the Laurentian. The Serra do Mar and the Serra do Mantiqueira, farther south in Brazil, are made up of the same formation.

The second or upper series, composed mostly of quartzites, metamorphic schists and crystalline limestones, probably represents both the Huronian and Lower Silurian, as an apparent difference in age is exhibited in the exposures of these rocks. To the Lower Silurian are referred, as before, the itacolumites and talcose schists of Minas Geraes. The metamorphic rocks are generally well exposed in the falls and rapids of the several tributaries of the Amazonas, the upper, or non-crystalline series being usually the first reached in ascending these rivers.

The southern edge of the metamorphic deposits of the Guayanian plateau, beginning near the Atlantic, in about 1° north, extends a little south of west to near the confluence of the Rios Negro and Branco, between latitudes 1° and 2° south; the northern edge of the same rocks in the plateau of Brazil presents a line of exposures, which pass the Tocantins, between 3° and 4° S., the Tapajos, between 4° and 5° S., and the Madeira, between 8° and 9° S. The edges of the metamorphic regions, thus defined, mark approximately the borders of the ancient channel, which existed between the primitive islands of Brazil, and in which were laid down, without great changes of level, or disturbances, the newer formations from the Upper Silurian to the Cretaceous inclusive.

There is a certain concordance in stratification between the

beds of the two series of the metamorphic deposits, but the evidence goes to prove that the older, or Laurentian, had been more or less disturbed and metamorphosed, before the deposition of the newer, although the great general movement of upheaval, that affected, and gave character to, the entire metamorphic region of Brazil, was posterior to both.

The formations above the metamorphic, so far observed in the Lower Amazonian valley, are the Upper Silurian, Devonian, Carboniferous, Cretaceous and Tertiary. The Upper Silurian immediately follows the metamorphic series, on the north side of the valley, but has not yet been recognized to the south of the Amazonas. On the Rios Trombetas, Curuá and Maecurú, where they were examined by Mr. Derby and his party, the rocks of this formation are exposed over an area of only a few miles in width, have an estimated thickness of about 1,000 feet, and rest upon felsite and syenite; they are very gently inclined, and consist mostly of thin-bedded, argillaceous and micaceous sandstones, with some massive beds of pure sandstone. In the lower part of the series, on the Trombetas, are fossiliferous beds, containing in addition to other species, *Arthrophycus Harlani* Hall, *Lingula cuneata* Con., *Orthis hybrida* Sow. and *Bucania trilobata* Con., which indicate an horizon corresponding to the Medina Sandstone of the Niagara group of North America.

The Devonian rocks occupy a broader superficial area than the Upper Silurian, but, so far as studied, are of less thickness,—about 530 feet. They have been traced northward from Ereré, where they were first discovered by Prof. Hartt, in 1870, a distance of about seventy-five miles, on the Rios Maecurú and Curuá. Three sections or groups were readily distinguished, differing from one another, both in lithological characters and in fossils. The lower, or Maecurú group, having a thickness of about thirty feet, consists entirely of coarse sandstones, and is very fossiliferous. The only fossils of this section that have been determined are the Brachiopods, which prove that the section is closely related to the Upper Helderberg of North America, but has also many characters in common with the Hamilton group.

The second or Ereré group has an estimated thickness of about 200 feet, is made up mostly of fine-grained micaceous sandstones, with some beds of black shale, and is underlaid by beds of cherts. The fossils, which are mostly Brachiopods, are in part identical with those of the Maecurú, in part, with those of the Hamilton group of North America. The upper group, called the Curuá, is about 300 feet thick, and consists almost entirely of black and yellowish shales, passing at times into shaly sandstones. The only recognizable fossils discovered

were *Spirophytons*, apparently belonging to the same species as those described from the Hamilton group of New York.

The Devonian rocks in the Ereré region have suffered greatly by denudation, and are much dislocated and divided by trap dykes, making their study very difficult. Beds apparently of Devonian age have been found as far west as the Rio Uatumá, and, to the south of the Amazonas, on the Tapajos and Xingú.

Of all the Paleozoic deposits of the Amazonian valley, the Carboniferous is exposed over the largest area, but, at the same time, presents the greatest difficulties to study. Being composed for the most part of soft rocks, it has been much denuded only widely-separated exposures remaining, of which it is difficult to determine the correlation of the several beds. It is, therefore, also impossible to estimate with certainty the thickness of the series, which probably exceeds 1,800 feet. The rocks are soft sandstones, shales and limestones, of which the latter, though having the least thickness, are the most important, from their being the best preserved and the richest in fossil remains. The fossiliferous beds, originally studied by Prof. Hartt and Mr. Derby on the Tapajos, were traced to the north of the Amazonas, on the Rios Maecurú, Curuá, etc. The different exposures, however, appear to represent about the same limited horizon, characterized by identical fossils.

The region over which the Carboniferous has been actually observed, is defined by Mr. Derby as follows: On the south side of the valley, it reaches up the Tapajos, to near the base of the rapids; westward it extends to, or beyond, the Rio Mauhéassú, situated midway between the Tapajos and Madeira, and eastward to, or beyond, the Xingú. To the north of the Amazonas, it stretches some distance northward of the region of Alenquer, partially covering up the Devonian between Ereré and the Maecurú locality, and has been found to the west, on the Rio Uatumá, and to the east, on the Rio Jauary near Prainha. There can be no doubt but that the Carboniferous really extends much farther west, and eastward, to near the Atlantic. From what has been said before, however, it will be understood that this formation is not exposed over the entire region above defined, although at one time it must have been continuous there. It was observed on the principal rivers mentioned, generally in the vicinity of the lower falls or rapids, and also at many intermediate localities, but is mostly covered up by more recent formations, or by dense forest growths, and over large tracts has been completely swept away. Notwithstanding the fact that the fossils of this group indicate an horizon, equivalent to the Coal Measures of North America, no seams of coal have yet been found on the Amazonas. The beds lie as a rule nearly horizontal.

Mr. Derby refers the sandstone hills of the Ereré series, which surround the Devonian plain of the same name, to the Cretaceous, from a study of the leaves of dicotyledonous plants, contained in some of the beds. These hills, which are composed of inclined strata, were elevated during, or at the close of, the Cretaceous age, as a broad anticlinal ridge, afterwards denuded away in the central portion, so as to uncover the Devonian plain, and leave the present series of monoclinal ridges, disposed in the shape of an ellipse.

Much of Mr. Derby's paper is also devoted to the extensive Tertiary deposits and the *varzea* of the Amazonian valley, subjects already treated of at some length by Prof. Hartt.

Art. LX.—*First Catalogue of Radiant Points of Meteors;* by Edwin F. Sawyer.

The following meteoric radiant points have been deduced from my observations, embracing the recorded paths of nearly 600 shooting stars, seen during the last two years (1877–8) at Cambridge, Mass. Among the number may possibly be found one or two doubtful positions, and a few strongly suspected and probably new showers requiring confirmation. The other positions either confirm those deduced by other observers, and heretofore considered rather doubtful, or are those of old and well established meteor systems. The limits of duration of the several showers are naturally uncertain; the results showing only the observed duration, and not the true period, which important element should receive the closest attention of observers in the future. Considerable complication has arisen from the large number of known radiants, and more attention should be given to establishing and identifying beyond a doubt the true positions of those already catalogued, with their limits of duration, than to the discovery of new and in many cases no doubt pseudo-meteor streams.

The theoretical shifting of the radiant point of a shower from day to day as the earth changes its position, should also, it seems (in the majority of cases), be practically shown in deducing the results; although the approximate character of this class of observations, renders it difficult to notice any shifting of position at intervals of less than a week. This important point should engage the attention of all observers, as going far to demonstrate the period of long enduring showers.

In deducing my results, great care has not only been exercised in regarding the peculiarities of each individual meteor mapped, such as length of path, velocity, magnitude, etc., but

List of Radiant Points.

No. (Sawyer).	Dates of Observations.	Radiant point. R. A. Dec.	No. of Meteors.	Remarks.
1	1878. Dec. 31–Jan. 7.	97½° + 17°	8	Meteors faint and rapid, possibly a new shower. Radiant, very near γ Geminorum.
2	1878. Jan. 29–Feb. 3.	167 + 42	7	Quite faint, short and rapid meteors. Confirms Heis (M. 2), 169° + 45°, Jan. 16–Feb. 1.
3	1878. Feb. 24–26.	145 + 8	5	Meteors very faint, with medium velocity and length of path; one stationary meteor. Denning, from Italian Met. Asso. Obs., 1872, at 147° + 4°, Feb. 1–Mar. 12.
4	1878. March 26–31.	204 + 34	4	Meteors quite brilliant and slow, with medium length of path. Evidently confirms Greg and Herschel, at 198° + 32°, Mar. 25–Apr. 24.
5	1877. May 3–7.	223 + 21	4	Meteors faint, short and rapid. Denning, at 220° + 21°, April 21, 1874. Radiant near ξ Bootis.
6	1877. June 24–July 3.	287 + 25	7	Meteors generally faint, short and quick. Radiant near β Cygni. Denning, at 285° + 32°, June 15–17, 1877. Tupman, at 280° + 29°, June 29–30, 1870.
7	1878. July 28.	337 − 33	4	Meteors bright and very slow, with long paths. Herschel, at 339°–34°, July 20–Sept. 20. Seen well by A. S. Herschel, July 28, 1865.
8	1878. July 21–23.	291 + 27	7	Meteors faint and quick, with medium length of path. Denning, from Italian Met. Asso. Obs., 1872, at 287° + 27°, July 15–Aug. 2. Compare No. 6.
9	1878. July 23.	285 + 49	5	Meteors quite bright, short and slow. Denning, from Italian Met. Asso. Obs., 1872, at 285° + 44°, July 15–Aug. 2.
10	1877. Aug. 10.	43–56	41	Perseids. Meteors brilliant, with quite long paths. Duration of observation, ¾ of an hour. Horary No. 55.
	1877. Aug. 11.	43 + 57	12	Observation from 9.30 to 10.30. Meteors bright and short.
	1878. Aug. 10.	44 + 56½	58	Meteors very bright, short and rapid. Duration of observation 1¾ hours. Horary No. 33. Position deduced from one stationary meteor and several short tracks near the focus.
11	1878. Aug. 10.	8 + 55	8	Meteors bright, short and rapid. Confirms Denning, at 8° + 53°, Aug. 3–16, 1877. Radiant between α and ξ Cassiopeiæ.
12	1878. Aug. 23–Sept. 1.	282 + 42	21	Active shower; meteors bright and rapid, with quite long paths. Mean of 5 positions from Greg's Table, 1876, at 281° + 38°, July 29–Sept. 25.
13	1878. Aug. 25–Sept. 1.	335 + 64	6	Meteors generally bright, short and rapid. Greg and Herschel, at 335° + 67°, Aug. 6–31. Schiaparelli and Zezioli, at 340° + 65°, Aug. 28.
14	1878. Aug. 25–30.	237 + 65	11	Position well deduced; meteors bright, short and rapid. Denning, from Italian Met. Asso. Obs., 1872, at 235° + 65°, Aug. 24–Sept. 14.
15	1878. Aug. 20–27.	274 + 20	7	Short, quick meteors. Denning, from Italian Met. Asso. Obs., 1872, at 270° + 20°, Aug. 24–Sept. 14.
16	1878. Sept. 30–Oct. 2.	23 + 17	7	Strongly suspected, and possibly a new shower. Meteors quite bright, short and rapid.

List of Radiant Points.

No. (Sawyer).	Dates of Observations.	Radiant point. R. A.	Radiant point. Dec.	No. of Meteors.	Remarks.
17	1878. Sept. 27–30.	3°	+21°	7	Exact. Meteors bright, short and swift. A new shower. ?
18	1878. Sept. 18–27.	333	+23	5	Rather uncertain. Meteors bright, short and slow. Denning, from Italian Met. Asso. Obs., 1872, at 333° + 27°, Aug. 24–Sept. 14.
19	1877. Oct. 28.	356	+40	8	Position exact. Active shower, 8 recorded during ¾ of an hour; early eve. Meteors faint and short. Schiaparelli and Zizioli, at 352° + 41, Nov. 13.
20	1878. Oct. 17–22.	28	+33	6	Meteors generally quite bright, short and rapid. Confirmed by H. Corder, Oct. 22–31, ? 1878, at 32° + 34° Radiant near ε Triangulorum. Possibly new.
21	1878. Oct. 21–22.	47	+27	4	Faint, short and rapid meteors. Greg and Herschel, at 43° + 26°. Oct. 18–Nov. 13. Denning, at 47° + 28°, Oct. 8; and from Italian Met. Asso. Obs., 1872, at 45° + 26°, Oct. 29–Nov. 13.
22	1878. Oct. 20–29.	24	+19	9	Meteors bright, short and generally rapid. Radiant near β Arietis. Gruber, at 21° + 22°, Oct. 17–24.
23	1877. Oct. 30–Nov. 11.	30	+21	7	Meteors faint, with short paths. Radiant near α Arietis. Evidently confirms Tupman (94), at 30° + 22°, Nov. 3, 1869. Compare No. 22.
24	1877. Nov. 4–11.	60	+18	5	Taurids I. Meteors generally quite brilliant, with medium length of path. Denning, average position at 60° + 20°, Oct. 17–Nov. 13, 1877.
25	1877. Nov. 30–Dec. 9.	80	+22	10	Taurids II. Meteors generally quite bright and quick, with medium length of path. Denning, Nov. 25–Dec. 13, at 80° + 25°.
	1878. Nov. 26–29.	82	+21	9	Meteors quite bright, generally slow, with medium length of path. Principally seen on Nov. 29.
26	1878. Nov. 24.	330	+63	4	Strongly suspected. Meteors faint, quick and short, and recorded during 1 hour's observation in W. Denning, from Met. Ass. Obs., 1872, at 330° + 66°, Nov. 25–Dec. 31.
27	1878. Nov. 23–29.	76	+46	8	Rapid, short and faint meteors. 3 recorded in rapid succession on the 24th. Position exact. Confirms a radiant deduced at Pola, Nov. 27, 1872, at 76°.5 + 46°.
28	1878. Nov. 24–29.	25	+26	5	Meteors quite bright, short and slow. Denning, from Italian Met. Asso. Obs., 1872, at 24° + 27°, Nov. 25–Dec. 31.
29	1877. Dec. 1–9.	97	+16	6	Meteors generally faint, with very rapid motion. Possibly new. Radiant center very near γ Geminorum. Compare No. 1.
30	1877. Dec. 7–9.	54	+35	4	Strongly suspected. Meteors quite faint and quick, with quite long paths.
31	1877. Dec. 28–29.	104	+33	5	Geminids. Meteors faint, short and quick.
&	1878, Dec. 22–26.	102	+35	5	Geminids. Meteors faint, short and quick.
32	1878, Dec. 25.	114	+18	5	Meteors generally bright, short and rapid; all recorded during 1 hour's watch; good radiation. Schmidt, Jan., at R. A., 115° +15°.

during the past year a certain weight has been attached to each meteor mapped, showing the accuracy of the path recorded, on a scale of one to four, and its corresponding value used in deducing the centers of radiation ; and the results are believed to be as nearly correct as the number of meteors recorded and the nature of the observations will allow. Observations were taken nearly every fair night in the absence of the moonlight, but were confined principally to the evening hours, between 6 and 11 P. M. The exceptions were morning watches in April, 1878, August, 1877–8, and November, 1877–8, for the appearance of the Lyraids, Perseids, and Leonids. With the exception of the Perseids, these gave negative results; only two or three scattering members from each stream being recorded. The periods of watching each evening varied from one to four hours in duration, and aggregate 187 hours in all. The observations were mostly confined to the eastern quarter of the sky, the few exceptions being watches in the west during the months of August, September and November, 1878.

In deducing the results, the method employed by Prof. Schiaparelli, (i. e. deducing the material obtained from each evening's observations, or those of a few evenings at most), has been used. The positions deduced from less than four meteors (of which there were a large number), have been rejected. In giving weight to the different positions deduced by me, observers should bear in mind that the small number of meteors, recorded in many of the cases, result from one or more of the following causes:

I. The shortness of the period from which each shower is deduced, averaging about five days, the average period of most observers being from twenty to thirty days. II. To the generally unfavorable hours, between which the observations were taken, before midnight, when meteors are much less abundant, than during the morning hours. III. To the small number of hours during which I was able to watch each evening, especially in the spring and winter months; several showers being deduced from one or two hours' watch only.

Corresponding observations of the same meteors are doubtless of great value in determining the heights, etc., of the meteors, as well as their radiant points, and during the latter part of last August, the writer together with Mr. Seth C. Chandler, Jr., made a series of observations at stations some seventy miles apart; the reduction of the same is now being done by Mr. Chandler.

Another series has been partly arranged and carried out by the writer and Mr. Oliver C. Wendell, of Lowell, Mass., and it is to be hoped that other observers will, during the coming year, be found willing to engage in this important work.

ART. LXI.—*Notice of recent Additions to the Marine Fauna of the Eastern coast of North America, No. 5*; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLII.

OF Polyzoa about 140 species have been identified by the writer from the coast between Cape Cod and Labrador. Nearly all these are Arctic or European species, already known. They are mostly described in Smitt's papers on Arctic Bryozoa. They are also mostly enumerated by the writer, in a Check-list of the Marine Invertebrata of this coast, now in type. The following is one of the more interesting new forms.

The recent determination of so large a number of American Polyzoa, confirms the decision already arrived at, several years ago, from the study of other classes, that the fauna of northern New England is remarkably arctic and chiefly of northern origin, and that the fauna of Greenland is more allied to that of Northeastern America than to that of Northern Europe. In a valuable paper* on the Podophthalmous Crustacea of our northern coast, just published, Professor S. I. Smith has arrived at the same results for that group.

Bugulella, gen. nov.

Stems slender, dichotomously branched, consisting of single series of cells (zoœcia), which are connected by short tubular joints that arise medially, from the back and near the distal end of the preceding cell, either singly or two together. Zoœcia elongated, expanded distally, with a large, sunken, elliptical frontal area on the front side, close to the end; gradually tapered to the proximal end, which is united, by an articulation, with the tubular process of the preceding cell, representing the stem. New branches arise laterally from these small joints. Frontal area surrounded by spines. Oœcia subglobular, attached to the distal end of the zoœcia. Avicularia median, at the distal end of the zoœcia, shaped as in *Bugula*. Allied to *Bicellaria* and perhaps to *Brettia*.

Bugulella fragilis, sp. nov.

Zoarium translucent, shining, delicate, filiform, much branched; forming intricate divaricate clusters, sometimes an inch or more in height. Apertures broad oval or elliptical, oblique, with a distinct rim, and with five spines, on each side; of these the two nearest the distal end are much shorter than the other three, which are as long as the breadth of the aperture, and arch over it. Sometimes a median spine is also present at the proximal edge. Ovicells globose, prominent,

* The Stalk-eyed Crustaceans of the Atlantic Coast of North America north of Cape Cod. Trans. Connecticut Acad., vol. v, Part I, May, 1879.

nearly as wide as the zoœcial apertures, smooth, shining, sometimes sculptured with raised lines, or with rounded sunken areas on the sides. A small oval disk on the lateral surfaces of the zoœcia. Avicularia small, with a rather short, thick, swollen head, the pedicel shorter than the vertical diameter of the head, attached to the distal end of the zoœcia.

East of George's Bank, 220 fathoms, on *Acanella Normani*. Presented to the U. S. Fish Commission by the captain and crew of the schooner "Alice G. Wunson."

Echinodermata.

Solaster Earllii, sp. nov.

A large, handsome species. Arms nine in our specimen, elongated, tapering. Upper surface thickly covered with clusters of divergent spinules, mostly six to eight, much smaller and shorter than in *C. papposus*. Marginal plates large, prominent, the largest bearing about twenty spinules, in two transverse rows. Ventral plates with about seven or eight long acute spines in one transverse row. Adambulacral plates with about five shorter, more slender spines. Greatest diameter 180^{mm}; lesser 50^{mm}. Taken in lat. 43° 24′; long. 59° 46′, in 200 to 250 fathoms, by the schooner "Bessie W. Somers," and presented to the U. S. Fish Com. by Capt. Thomas F. Hayden.

Dedicated to Mr. R. E. Earll of the U. S. Fish Commission.

Molpadia turgida, sp. nov.

Body large, elongated, turgid, suddenly tapering posteriorly to the slender, moderately long caudal portion. Tentacles short, almost rudimentary, two-lobed, seldom expanded. Skin thin, often somewhat translucent, dark reddish or purplish brown, filled with perforated table-shaped or spinulated plates, and with numerous regular, circular and oval, biscuit-shaped orange-brown calcareous grains, of various sizes, less numerous than in *M. oölitica*, but far more numerous and more regular than in *M. borealis*. These grains have a concentric structure, either around one, or, when oval, around two nuclei. The perforated plates are rather large and irregular, but delicately formed, much less irregular and larger than in *M. borealis*. They usually have a central circle of three to six foramina, then a circle of ten or more, larger, oval foramina, separated by a thin framework, which runs out into irregular projections beyond the border; the central spinule is elongated, acute, consisting of three or four columns. The largest specimens are about 125^{mm} long, and 25 to 30^{mm} in diameter.

Bay of Fundy,—A. E. Verrill and S. I. Smith, 1865. Massachusetts Bay, 40–100 fath., soft mud, 1877, '78; Gulf of Maine, 1874; Casco Bay, 1873; off Nova Scotia, 1877,—U. S. Fish Commission. Gulf of St. Lawrence, Whiteaves.

ANTHOZOA.

Actinernus, gen. nov.

Body large, short, smooth. The margin below the tentacles is deeply divided into acute lobes, or teeth, continuous with the body-wall. The tentacles are rather large, and adnate to the marginal lobes for a considerable part of their length. Disk large, with the margin undulate or frilled in large specimens. The disk and tentacles apparently are not retractile.

Actinernus nobilis, sp. nov.

Body stout, with a very broad basal disk and short column, and toward the summit thrown into about eight large undulations or folds, bending outward and inward, corresponding to the lobes of the disk; the margin is deeply cut into sharp conical teeth, corresponding to the tentacles in number and position, and like them alternating in an inner and outer row; integument of column and teeth thick, firm and smooth. Tentacles numerous, elongated, tapering, acute, moderately large, subequal, in two rows close to the margin, adnate to the marginal teeth for about two-thirds of their length, or even more. Lips well-developed, with about eight large lobes on each side. Color, in recently preserved specimens, deep purplish brown on the disk and tentacles, with radiating lines of paler color on the disk; mouth deep brown inside; sides of body milk-white, with traces of orange-color where the outer coat remains.

Largest specimens, in alcohol, about four inches broad and three high. Four specimens were presented to the U. S. Fish Commission.

Off Sable I., N. S., 200–250 fathoms, Aug., and Banquereau, about 200 fathoms, Sept. 9, 1878,—Capt. J. W. Collins, sch. "Marion." Eastern slope of George's Bank, in about 220 fathoms,—Capt. and crew of the sch. "Alice G. Wunson," Sept., 1878. Lat. 42′ 31°; long. 64° 20′, 300 fathoms,—Capt. Wm. H. Greenleaf, sch. "Chester R. Lawrence."

Synanthus, gen. nov.

Actiniæ which have a broadly expanded, thin base from which new zoöids arise by budding, so as to constitute a small colony, connected together by a common base. Integument thin and smooth. Tentacles numerous, retractile.

Synanthus mirabilis, sp. nov.

Colonies often consist of five or six, or more, zooids, which are generally parasitic upon the branches of *Primnoa reseda* and *Paragorgia arborea*, often surrounding them like a ligature, and in the case of *Paragorgia* often forming deep constrictions so as to seriously weaken the branches. Column low and button-like in contraction, the integument so translucent as to show the numerous internal radiating lamellæ. Same localities as for the preceding species.

ART. LXII.—*On a new Absolute Galvanometer;* by N. D. C. HODGES.

IN the ordinary form of galvanometer the current is measured by the ratio of the force it exerts on the needle to the directive force of the earth, the ratio being determined by a measurement of the angle of deflection.

The moment of the force with which a unit current acts on the needle may be expressed in a series of the form

$$G_1 g_1 \sin\theta + G_2 g_2 \sin\theta\, Q_2'(\theta) + \text{etc.}$$

where G_1, G_2 are constants depending on the dimensions of the coil, and g_1, g_2 on those of the suspended apparatus, coil or magnet, as the case may be. $Q_1'(\theta)$, $Q_2'(\theta)$ are quantities varying with the deflection.

Only in case all the terms after the first may be neglected are the values of the current proportional to the tangents of the deflections. With a single coil this is not the case. By increasing the number of coils and suitably placing them, the magnetic field may be rendered more uniform.

In reading the deflection either a divided circle or a telescope and scale may be used. With the divided circle the deflection may be as great as 45°, but not more, or else the instrument would not be sensitive to changes in the current. The use of telescope and scale necessitates much smaller deflections. To regulate the strength of the current shunts of small resistance often have to be used; and the proportion of the current through the instrument is rendered doubtful.

If, instead of placing the plane of the coils parallel with the magnetic meridian, they are placed perpendicular to it, the sum of the force of the current and of the directive force of the earth would influence the magnet.

The formula $$\frac{t^2}{\pi^2} = \frac{K}{MT(1+\theta)}$$

expresses the relation between the time of vibration of a horizontal, swinging magnet, its moment of inertia K, its magnetic moment M, and the horizontal component of the earth's magnetic force T.

If this time, the time of vibration without the current, is first taken and then the time t_i with the current, we get the relation between the two,

$$\frac{t_i^2}{\pi^2} = \frac{K}{M(T+F)(1+\theta)}$$

$$\frac{t^2}{t_i^2} = \frac{T+F}{T} \quad \text{or} \quad \frac{t^2 - t_i^2}{t_i^2} = \frac{F}{T}$$

when F is the directive force of the current on a magnet of unit magnetic moment.

The moment of the force F on the magnet is

$$C\,(G_1 g_1 \sin\theta + G_1 g_1 \sin\theta\, Q_1'(\theta) + \text{etc.})$$
$$= \sin\theta\, C\,(G_1 g_1 + G_2 g_2\, Q_1'(\theta) + \text{etc.})$$

θ=the angle between the axis of the coil and of the magnet.

Hence $$C\,(G_1 g_1 + G_2 g_2\, Q_1'(\theta) + \text{etc.}) = F.$$

For the small angles through which the magnet need vibrate, this factor may be considered constant and equals the constant of the instrument, used as a tangent galvanometer, when the deflection is supposed equal to 90°.

Let $G_1 g_1 + G_2 g_2 Q_1'(0°) + \text{etc.} = K_{90°}$.
Then $F = CK_{90°}$

The value of C is obtained in the form

$$C = \frac{t^2 - t_1^2}{t_1^2}\,\frac{T}{K_{90°}}$$

To find the value of $K_{90°}$ the same current, if passed through the instrument used as a tangent galvanometer, will give

$$C = \frac{T}{K\varphi}\tan\varphi$$

Hence $$\frac{T}{K\varphi}\tan\varphi = \frac{t^2 - t_1^2}{t_1^2}\,\frac{T}{K_{90}}$$

or $$K_{90} = \frac{(t^2 - t_1^2)\,K\varphi}{t_1^2\tan\varphi}$$

If the value of $K\phi$ is known for any value of φ, the deflection, the constant of the instrument used in this other way is given by this formula.

It is evident that the relative values of $K\phi$ for different values of the deflection of a tangent galvanometer may be found by repeated application of this process.

$$K_{90} = \frac{t^2 - t_1^2}{t_1^2}\,\frac{K\varphi}{\tan\varphi}$$
$$K_{90} = \frac{t^2 - t_2^2}{t_2^2}\,\frac{K\varphi_1}{\tan\varphi_1}$$
$$\therefore\quad \frac{K\varphi}{K\varphi_1} = \frac{\tan\varphi}{\tan\varphi_1}\,\frac{t^2 - t_2^2}{t_2^2},\ \frac{t_1^2}{t^2 - t_1^2}$$

Any of the usual methods for finding the constant of a galvanometer would also apply.

Physical Laboratory, Harvard College, Feb. 12, 1879.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a New Series of Molecules.*—In 1868, Angus Smith made an investigation into the absorption of gases by charcoal, believing that, since this action was on the border line between physics and chemistry, it would throw some light on chemical phenomena. The results then obtained showed that the gases were absorbed in whole volumes, hydrogen being 1, oxygen 7·99, carbonous oxide 6·03, carbon dioxide 22·05, marsh gas 10·01, nitrogen monoxide 12·90, sulphurous oxide 36·95, and nitrogen 4·27. The author has now taken up the subject anew and finds that charcoal does actually absorb gases in perfectly definite volumes, the physical action being like the chemical. Thus calling the volume of hydrogen absorbed 1, that of the oxygen is 8, the proportions by volume being the same as those by weight in chemical union. Moreover, since oxygen is 16 times heavier than hydrogen, charcoal absorbs 128 times more oxygen than hydrogen by weight. Now this number is exactly equal to the density of oxygen squared and divided by two, $\frac{16^2}{2}$, or it is half the product of the density of this gas and its atomic weight. Again, the most probable value for nitrogen is 4·66 volumes absorbed, and hence the weight absorbed is $14 \times 4{\cdot}66$ or 65·3. This number is $\frac{14^2}{3}$, since nitrogen is trivalent. Carbon dioxide is not divided but is simply 22^2. The carbonous oxide absorbed is 6 volumes, the carbon dioxide $6+16=22$ volumes, marsh gas $6+4=10$ volumes, nitrogen monoxide $8+4{\cdot}66=12{\cdot}66$ volumes. These figures seem to the author to suggest a new series of molecules, whose weights are produced by squaring the atomic weights and by certain divisions peculiar to the gases in question. It may be perhaps that the larger molecule exists in the free gas and is broken up on chemical combination. The building up of a molecule by volumes in this way suggests the possibility at least that our present molecules may be similarly constructed.—*Proc. Roy. Soc.*, Feb. 6, 1879. *Nature*, xix, 354, Feb. 1879. G. F. B.

2. *On the Reciprocal Displacement of Oxygen, Sulphur, and the Halogens, when combined with Hydrogen.*—Berthelot has studied the reciprocal displacements which take place in the so-called hydracids and finds that these also are regulated by the value of the heat of combination. Thus for example, experiment has given him the following equivalent numbers:

H+Cl	=HCl gas	+22·0	HCl dissolved	+39·3
H+Br gas	=HBr gas	+13·5	HBr dissolved	+33·5
H+I gas	=HI gas	—0·8	HI dissolved	+18·6
H+S gas	=HS gas	+3·6	HS dissolved	+ 5·8
H+O gas	=HO gas	+29·5	HO liquid	+34·5

From these numbers it follows: 1st, that Cl should displace Br and I, and Br should displace I, in the hydracids both when gaseous and in solution; this is common knowledge; 2d, that Cl and Br should displace S in hydrogen sulphide either gaseous or dissolved,—also a well known reaction; 3d, that I should displace sulphur in hydrogen sulphide in solution, forming HI dilute; but that S on the contrary should decompose gaseous HI, forming hydrogen sulphide. These facts were experimentally established by placing hydrogen sulphide in a sealed tube containing I, and heating to 500°; no reaction took place. But HI gas on the contrary reacts on S even in the cold, and if the tube be opened under water, the latter rises in the tube, remaining transparent till the inverse reaction takes place in solution, the iodine decomposing now the hydrogen sulphide again, with deposition of sulphur. 4th, that oxygen should displace S from hydrogen sulphide, a common reaction; 5th, that between chlorine and oxygen, an equilibrium should be produced, since on the one side gaseous chlorine should decompose water to form HCl in solution, and on the other gaseous oxygen should decompose dry HCl gas, to form water and chlorine. In proof of this, Berthelot mixed HCl and O in a sealed tube and passed sparks through the tube for several hours with the result, that nine-tenths of the HCl was decomposed, while a similar experiment with water vapor and Cl gave no result. 6th, that O should displace Br from HBr either gaseous or dissolved; and 7th, that oxygen should displace I, under the same circumstances, a fact well shown by the fact that a mixture of four volumes of HI and one of oxygen readily takes fire and burns with a red flame, a good lecture experiment. The inverse reaction does not take place.—*Bull. Soc. Ch.*, II, xxxi, 309, April, 1879.
G. F. B.

3. *On the Liquefaction of Hydrogen Silicide.*—OGIER, in the laboratory of Berthelot, has prepared hydrogen silicide pure and has succeeded in liquefying it by means of the apparatus devised by Cailletet. At ordinary temperatures, about 10°, this gas sustained a pressure of 200 to 300 atmospheres without being liquefied. But on sudden expansion, even at fifty atmospheres, the cooling produces a thick mist and droplets appear on the walls of the tube. Under these conditions the gas is evidently very near its critical point. Indeed, cooling it only a few degrees below zero suffices to condense it totally. Under a pressure of fifty atmospheres it is liquid at −11°; of seventy atmospheres, at −5°; and of 100 atmospheres, at −1°. At zero, on the contrary, it remains gaseous even at 150 to 200 atmospheres. The critical point is therefore not far from zero.—*C. R.*, lxxxviii, 236, Feb. 1879.
G. F. B.

4. *On the Ytterbia of Marignac, and on a New Element, Scandium.*—NILSON, who was on the point of commencing an investigation of the gadolinite and euxenite earths when Marignac's paper appeared, has proceeded with it since this chemist has given it up for want of material. Having 63 grams of erbia, the

molecular weight of which was 129·25, he sought at first to separate the ytterbia by a modification of Marignac's process, ceasing to heat the melted mass so soon as red fumes appeared. But it proved too tedious and he returned to the unmodified method. After thirteen series of decompositions of the nitrates by heat, there remained a basic nitrate which showed only feeble absorption bands in the green and red. The solution, precipitated with oxalic acid, was evaporated and gave 3·5 grams of a white earth with a scarcely perceptible rose tint, whose molecular weight was 127·64. This low number led the author to suspect the presence of a new element in the ytterbia, and a portion of the chloride was submitted to Thalén who found lines differing from any previously observed in this group. The earth was converted into nitrate, a suitable quantity of sulphuric acid was added, the solution was evaporated, finally over a naked fire, but at such a temperature that the residue dissolved perfectly in water. The molecular weight of the earth diminished gradually until it reached 105·83, and yet traces of ytterbia were present. Examined again spectroscopically by Thalén, it gave twenty-nine lines, the strongest of which had wave lengths of 6078·5, 6054, 6019, 5736, 5729, 5719, 5710·5, 5700, 5686, 5671, 5657·5, 5526, 5089, 5084·5, 5082·3, 4739, 4736·5, 4733. To the element thus established, Nilson gives the name *Scandium*, since the two minerals gadolinite and euxenite in which it occurs are of Scandinavian origin. Its oxide is a colorless earth, the solutions of which give no absorption bands. It is after calcination attacked with difficulty by dilute nitric acid, more readily by hydrochloric. Oxalic acid precipitates it completely. The nitrate is completely decomposed at a temperature at which ytterbium nitrate is only partially converted into a basic salt. Its sulphate is not changed at high temperatures, but is completely decomposed by calcination with ammonium carbonate. Calculated from ScO, the atomic weight cannot be far from 90; though if scandia be Sc_2O_3, the at. wt. would be 135.

The solutions from which the various basic nitrates had deposited were then submitted to examination. The result showed that while the molecular weight of the earth which had precipitated from the solution as basic nitrate continued to diminish, that of the earth which remained in solution remained constantly the same, about 131. Eight of the mother liquors gave a substance whose molecular weight was above 131. Treated again by Marignac's method eight times, these afforded 3·5 grams of an earth of a molecular weight of 131·63, the fused nitrate of which gave only a single feeble erbia absorption band in the green. Repeating the operation, the last traces of erbia were eliminated and the ytterbia obtained pure, its nitrate showing no absorption bands. The erbia of previous authors then is nearly all ytterbia and only a few per cent erbia. The author hopes to study erbia, ytterbia and scandia more carefully, since he has in conjunction with Clève, begun work on ten kilograms each of gadolinite and euxenite.—*C. R.*, lxxxviii, 642, 645, March, 1879. G. F. B.

5. *On an Amidonitrosulphide of Iron.*—DEMEL has repeated the experiment of acting upon a ferrous solution with potassium nitrite and ammonium sulphide, first noticed by Roussin, in order to study more carefully the product. To prepare the compound, 20 grams potassium nitrite is dissolved in 300 c. c. water, the solution is heated to boiling, 40 c. c. ordinary ammonium sulphide solution is added, and the heating continued for a few minutes. A solution of 33 grams crystallized ferrous sulphate in 200 c.c. water is then added gradually with shaking and the liquid boiled for ten minutes. It is then filtered and the filtrate deposits black needle-shaped crystals, which after recrystallization from water are obtained as brilliant black prisms. They decompose in the air, are easily soluble in water, alcohol and ether, evolve H_2S with dilute and brown vapors with strong HCl, and give off ammonia when boiled with KOH. Even below 100° this body decomposes, evolves heat and leaves ferrous sulphide. Analysis showed that the nitrogen was united partly to oxygen and partly to hydrogen, all the hydrogen being united to nitrogen. The numbers obtained gave the empirical formula $FeSN_2H_2O_2$, from which and the facts above given the rational formula must be $\begin{array}{l} Fe\left\{\begin{array}{l}NO_2\\ SNH_2\end{array}\right.\\ \;\Vert \\ Fe\left\{\begin{array}{l}SNH_2\\ NO_2\end{array}\right.\end{array}$. Similar compounds with nickel, cobalt or manganese have not yet been obtained.—*Ber. Berl. Chem. Ges.*, xii, 461, March, 1879.

G. F. B.

6. *On a New Method of producing Ketones.*—VON BECHI has modified the method for preparing ketones originally suggested by Freund. In place of using zinc radicals, he employs iodides of the alcohol radicals in presence of sodium. In a dilute etherial solution of equal molecules of ethyl iodide and benzoyl chloride, well cooled, is placed the necessary quantity of sodium; at first no action is observable, but soon a yellow powder separates consisting of sodium iodide and chloride. After 48 hours, the whole is extracted with ether and the ether evaporated. A brown liquid is left, which washed with water and fractionated, distills between 205° and 210°, is a light yellow refractive oil of agreeable odor having the composition of phenylethylketone. The reaction is as follows:

$$\left\{\begin{array}{l}C_6H_5\\ COCl\end{array}\right. + \left\{\begin{array}{l}C_2H_5\\ I\end{array}\right. + Na_2 = NaI + NaCl + CO\left\{\begin{array}{l}C_6H_5\\ C_2H_5\end{array}\right. .$$

The method appears general.—*Ber. Berl. Chem. Ges.*, xii, 463, March, 1879. G. F. B.

7. *On the Production of Aurin.*—CLERMONT and FROMMEL have succeeded in producing aurin directly by acting upon phenol by a mixture of carbonous oxide and oxygen in sealed tubes.

$$(C_6H_5OH)_3 + CO_2 = \begin{array}{l}C_6H_4OH\\ C_6H_4OH\end{array}\Big\}\, C\left\{\begin{array}{l}C_6H_4\\ O\end{array}\right\} .$$

The CO_2 must be nascent to produce the effect.—*C. R.*, lxxxviii, 655, March, 1879. G. F. B.

8. *Radiometer.*—In recent numbers of *Nature* (April 3rd and April 10th, 1879), Mr. W. Crookes gives an abstract of his later researches on the "Repulsion resulting from Radiation." He first discusses the amount of repulsion produced by radiation on disks of various kinds and coated with different substances. The very delicate and ingenious apparatus, by which the repulsive forces were compared, is described at length; and the description shows what great skill has been acquired in controlling the obscure phenomena, which Mr. Crookes has so successfully elucidated. For details and numerical results we must refer to the original papers. The repulsions were measured both when no screen was interposed, and also when a cell of water was inserted in the path of the rays; and the difference in the relative effects under these conditions is very striking. These phenomena, which are similar to those first described by Melloni under the name of "Thermocrosis" are among the most interesting results of the investigation. In order to compare the two classes of results, it was first determined that the actual amount of repulsion on a lamp-blacked disk, when the water-screen was interposed, was only one-twelfth of that exerted by the standard candle flame when no screen was in the way, the distance of the candle and other things being of course equal. With the effect on the standard lamp-blacked disk the other repulsions were compared and hence if the direct effect of the source employed on this disk is arbitrarily expressed by the number 100, the effect of the same source on the same disk through the given water screen but under otherwise identical conditions, would be, according to the determination just referred to, expressed by the number 8·3. The other numbers of the following table have a similar meaning.

	No screen.	Water screen interposed.	Per cents with water screen.
Lampblack (standard disk),	100·	8·3	100·
Chromic oxide (pale green),	71·5	1·7	20·4
Copper tungstate,	51·2	6·4	76·8
Prosulphocyanogen,	43·9	1·0	12·0
Saffranin,	41·0	4·3	51·6
Hydrated zinc oxide,	40·5	1·2	14·4
Barium sulphate,	37·4	0·3	3·6
Selenium precipitated,	35·8	5·8	69·6
Copper oxalate,	30·1	3·3	39 6
Calcium carbonate,	28·5	0·3	3·6

It appears from this table that the substances experimented on may be divided into two classes.

(1.) Negative: those in which the repulsion behind water bears a *greater* proportion to the standard than when no screen is interposed.

(2.) Positive: those in which the repulsion behind water bears a *less* proportion to the standard, than when no screen is interposed.

Amongst Class 1, are copper tungstate, saffranin, selenium and copper oxalate. Amongst Class 2, chromic oxide, persulphocyanogen, hydrated zinc oxide, barium sulphate and calcium carbonate. Evidently these differences must correspond to a difference in the capacity of absorbing the luminous and the non-luminous

ultra red rays, or in other words to the thermocrosis of the several pigments employed.

As might be expected, the differences of qualities just described are brought out most strikingly when coatings of opposite classes are balanced against each other on the vanes of the movable fly of a radiometer, and this instrument can be constructed with a movable glass cap made tight by cement, so that the fly may be removed and the vanes shifted at pleasure. We quote from Mr. Crookes's paper the following description of the singular results he thus obtained.

"Disks coated on alternate sides with chromic oxide and precipitated selenium move in one direction to the naked flame of a candle and in the other direction when a water screen is interposed. With saffranin and hydrated zinc oxide, the instrument does not move at all when exposed to the naked flame, but revolves when a water screen is interposed. With thallic oxide and Magnus's green platinum salt, the instrument moves strongly when no screen is interposed, but is stopped with a water-screen. These results are all in conformity with the figures."

"A pith radiometer coated with precipitated selenium and chromic oxide was exposed to the radiation from a colorless gas flame of a Bunsen burner, and also to the same colored intensely green by thallium. To the eye, by this light, the chromic oxide looked nearly white and the selenium black. The rotation due to the repulsion of the chromic oxide was however apparently as strong as when the non-luminous flame was used. This experiment proves that certain substances have an opposite absorptive action on rays of dark heat to what they have on light, and that an optically white body may be thermically black, and vice versa. In this case, for instance, chromic oxide was optically green and thermically black, while scarlet selenium was thermically white and optically black."

It was originally thought that a slice of tourmaline, being black to a ray of light polarized in one plane and white to a ray polarized in the other plane, would be repelled when the incident light was quenched by it, and not affected when the incident light passed through it. Mr. Crookes's measurements, however, show that this action does not exist to any appreciable degree. He experimented on a plate of tourmaline suspended in vacuo on a torsion balance, and measured the amount of repulsion produced by a beam of polarized light when in different planes, and he explains the negative results by saying that while the repulsion resulting from radiation is almost entirely a surface action, the action of a tourmaline on a polarizer is one in which thickness is necessary.

The analysis which Mr. Crookes next gives of the effect of the shape of the vanes of a radiometer in influencing the amount and direction of repulsion is very ingenious, and highly interesting; but the discussion cannot be made intelligible without the numerous figures with which the papers are illustrated. It is sufficient to say that the effects are shown to be in accordance with the

theory which Mr. Crookes has so fully worked out. One of the most remarkable of these effects is that produced by the viscosity of air which at a rarefaction of 129 millionths of an atmosphere, appears to be only a little less than its viscosity at the normal density, and hence the vanes of a radiometer at a speed of 100 revolutions a minute exert a considerable drag on a disk of mica rotating just above them.

In reading these very interesting papers one is greatly impressed by the perfection to which the mercury pump, and the means of measuring the degree of exhaustion which the pump produces, has been brought. In some of his experiments Mr. Crookes speaks of carrying the exhaustion to four ten-millionths of an atmosphere, and we quote as follows from the close of his article.

"In concluding this abstract of my researches on Repulsion resulting from Radiation I cannot refrain from pointing out how erroneous the ordinary ideas of a 'vacuum' are. Formerly an air pump which would diminish the volume of air in the receiver one thousand times was said to produce a vacuum. Later a 'perfect vacuum' was said to be produced by chemical absorption, and by the Sprengel pump, the test being that electricity would not pass; this point being reached when the air is rarefied one hundred thousand times. Now Mr. Johnston Stony has calculated that the number of molecules in a cubic centimeter of air at the ordinary pressure is probably something like one thousand trillions. When this number is divided by 2,500,000 there are still four hundred billion molecules in every cubic centimeter of gas at the highest exhaustion to which I carried the experiment, a rarefaction which would correspond to the density of the atmosphere about seventy-five miles above the earth's surface, that is, if its density decreases in geometrical progression as its height increases in arithmetical progression. Four hundred billion molecules in a cubic centimeter appear a sufficiently large number to justify the supposition that when set into vibration by a white hot wire they may be capable of exerting an enormous mechanical effect."

9. *The Magic Mirrors of Japan.*—The bronze mirrors of Japan are usually circular, from three to twelve inches in diameter, made of bronze, and with a bronze handle covered with bamboo. The reflecting face is generally more or less convex, polished with a mercury amalgam and the back is ornamented with a varied design. The magic property, which is only possessed by a few rare specimens, appears when a bright beam of light is reflected by the polished surface on to a screen. There is then seen on the screen an image formed of bright lines on a dark ground more or less perfectly representing the pattern on the back of the mirror, although not only is the latter wholly hidden from the light but also the polished surface itself, if looked at directly, acts like an ordinary mirror reflecting the objects in front of it, and giving no indications whatever of the raised patterns on the back. In the "Friday evening discourse at the Royal Institution" of Jan. 24, reported in *Nature* of April 10th, Prof. W. E. Ayrton gives a full

and satisfactory explanation of this remarkable effect, which so far from being intentional on the part of the manufacturers of the mirrors, appears to have been quite unknown to the Japanese, although known to the Chinese from the earliest times. It appeared from the experiments of Professor Ayrton that: 1, when a divergent beam of light fell on the mirror the pattern appeared as bright on a dark ground; 2, when the beam was parallel the pattern was invisible; 3, when the beam was convergent the pattern appeared as dark on a light ground. These and similar experiments exhibited by the lecturer all point to the conclusion that the effect is caused by inequalities in the curvature of the reflecting surface corresponding to the raised pattern on the back, the portions where the relief increases the thickness of the plate being flatter than the remaining convex surface, and even being sometimes actually concave. Professor Ayrton fully describes how such an irregular form would result from the peculiar mode by which the Japanese produce the polished surfaces; whenever the bronze casting is thus worked sufficiently thin to determine a "buckling" of the metal. This result is very exceptional. No thick mirror reflects the pattern on the back, and not more than two or three per cent of the ordinary Japanese bronze mirrors show the magic property clearly. J. P. C., JR.

II. Geology and Mineralogy.

1. *The Cincinnati Group.*—A committee was recently appointed by the Cincinnati Society of Natural History to consider "questions of geological nomenclature," and especially the propriety of using the term "Cincinnati Group," as first proposed by Meek, for the Hudson River Group, and the age of the Lower Silurian rocks of Southwestern Ohio, Southeastern Indiana and Kentucky. The following are extracts from this very satisfactory report.

"The fossils found in the strata, for twenty feet or more above low water mark of the Ohio river, in the first ward of the city of Cincinnati, and on Crawfish creek, in the eastern part of the city, and in Taylor's creek, east of Newport, Kentucky, at an elevation of more than fifty feet above low water mark in the Ohio river, indicate the age of the Utica Slate Group of New York. A fauna is represented in these rocks that is not found above or below them. Within this range we find the *Triarthus Beckii*, *Leperditia Byrnesi*, *Leptobolus lepis*, *Buthotrephis ramulosa*, and several species of Graptolites, Crinoids, Bryozoans and Brachiopods, that seem to be confined within its limits. * * *

"Above the range of the *Triarthus Beckii*, the fossils, as well as the position of the rocks, indicate the age of the Hudson River Group of New York, and we have no hesitation in so referring them, and entertain no doubt of the correctness of the reference. * * *

"In Southeastern Indiana neither the Trenton nor Utica slate appear, and, consequently, we refer all the Lower Silurian rocks of that State to the Hudson River Group.

"The Trenton Group is not exposed at Cincinnati, nor at any point in Ohio west of the city, but we think it is probable that it may be represented in the banks of the Ohio river a few miles east of the city. The Utica Slate is represented in Ohio only in the banks of the river, at the city of Cincinnati, and east of the city, and in the excavations near the mouths of the streams which enter the river east of the city. Consequently all the Lower Silurian rocks in Southwestern Ohio belong to the Hudson River Group, except those represented by the small exposures in the banks of the river at Cincinnati, and east of the city, in the immediate vicinity of the river.

"The conclusion to which we have come is, that all the Lower Silurian rocks which we have had under consideration, are to be referred to the Trenton, Utica Slate and Hudson River Groups, and that the name 'Cincinnati Group' should be dropped, not only because it is a synonym, but because its retention can subserve no useful purpose in the science, and because it will, in the future, as in the past, lead to erroneous views and fruitless discussion. And we would add that so far as any investigations of these rocks have been made, they have not led to any other or further subdivisions than those which we have adopted, and which have been so thoroughly and firmly established by the geologists of the State of New York."—Signed: S. A. Miller, Fred Braun, Jno. Mickleborough, John W. Hall, Jr., E. O. Ulrich, A. G. Wetherby, Geo. W. Harper, Paul Mohr, C. B. Dyer, R. M. Byrnes.

This Report, besides appearing in the publications of the Cincinnati Society, is also published in the tenth Annual Report of the Geological Survey of Indiana, where it is followed by a long list of the fossils found over the region referred to, in the Hudson River, Utica Slate and Trenton Groups, by S. A. Miller of Cincinnati.

2. *Atlas to the Coal Flora of Pennsylvania, and of Carboniferous Formations throughout the United States;* by LEO LESQUEREUX. Second Geological Survey of Pennsylvania.—This atlas by Mr. Lesquereux is a volume of eighty-seven plates, issued in advance of the volume of descriptive text. The plates are of remarkable beauty and perfection. The drawings were prepared with great care and the engraving is excellent. To Mr. Lesquereux, the author, and to Professor Lesley and the Geological Commissioners of Pennsylvania, who have had the volume published in such admirable style, the thanks of all friends of paleontological botany, the world over, will be given without stint. The work at once becomes the necessary hand-book for all who would study American coal plants. The atlas contains figures of 260 species which have been named and described by Mr. Lesquereux, and of these 122 are now for the first time figured.

Of his modifications of classification—such as his new genus Pseudopecopteris—we can better judge when the volume of text is received. Over thirty species of *Neuropteris* are figured, and more than twenty of Pecopteris, and the whole department of

fossil botany receives new illustrations from American specimens. Much light is thrown upon the Cordaites group, a class of Carboniferous plants hitherto a great puzzle to botanists. We shall notice this rich contribution to science more in detail when we have received the volume of descriptions.

3. *Materialien zur Mineralogie Russland, von Nikolai von Kokscharow.* Vol. viii, pp. 177–384, vol. ix, pp. 1–32.—Mineralogists will welcome an addition to the great work of Professor Kokscharof on the Mineralogy of Russia; the seventh volume is thus completed and an eighth commenced. The description of the crystalline form of each species considered is marked by the same accuracy and thoroughness that has characterized the work from the beginning. The following are the more important species described: Breunerite; pyrite; species of the mica group; waluewite (a new species near xanthophyllite); perofskite; eudialyte.

4. *Neues Jahrbuch für Mineralogie, Geologie and Paleontologie.*—The long known and highly valued Jahrbuch für Mineralogie, etc., has passed into the hands of a new corps of editors: Professor E. W. Benecke, in Strassburg, will have charge of the Geology and Paleontology; Prof. C. Klein, in Göttingen, of the Mineralogy; and Prof. H. Rosenbusch, in Heidelberg, of the Lithology. The first number under these editors has just appeared, (drittes u. viertes Heft, 1879). It contains a large number of original articles, and with the correspondence and extracts of papers in the different departments, covers 255 pages. The many workers in science who have used the Jahrbuch in years past, will wish for it a long-continued career of usefulness.

5. *Brief notices of some recently described Minerals*:—*Huntilite.* Described by Prof. Henry Wurtz, as occurring in two varieties. The most abundant variety is amorphous, often porous and crumbly, dark slate-gray, or almost black in color, and entirely dull in luster. The other kind has a lighter slate-color, a crystalline structure, and probably one cleavage; it is intimately associated with calcite. The hardness is 2·5; the streak is bronze-color; the mineral is sub-malleable. Analyses of the two kinds gave the following results:

1. Amorphous. 2. Crystallized.

	As	Sb	S	Hg	Ag	Co	Ni	Fe	Zn	H_2O	gangue.		
1.	21·10	3·33	0·78	1·04	59·00	3·92	1·96	3·06	2·42	0·19	3·23	=100·03	G.=7·47
2.	23·99	4·25	1·81	1·11	44·67	7·33	2·11	8·53	3·05	0·33	1·65	= 98·83	G.=6·27

The mercury is believed to be present as amalgam; the sulphur as pyrite; after the deduction of these, the following ratios are obtained, the arsenic and antimony being taken together, and all the metals combined, according to their quantivalences:—As : $\overset{\mathrm{I}}{R}$ = 1:2·90 (amorphous) and = 1:2·99 (crystalline). The general formula $AsAg_3$ is proposed, but the results of the analyses would suggest grave doubts as to the homogeneity of the material examined. Found at the Silver Islet Mine, Lake Superior. Named after Dr. T. Sterry Hunt.—*Engineer. and Mining J.*, Jan. 25, 1879.

Animikite. Announced provisionally by Prof. Wurtz. It occurs sometimes in incrustations over masses of huntilite; also in large isolated plates or slabs. Specific gravity =9·45. Color white or grayish-white. Fracture fine granular, conchoidal. An analysis gives: Sb 11·18, As ·35, S 1·49, Hg ·99, Ag 77·58, Co 2·10, Ni 1·90, Fe 1·68, Zn 0·30, gangue 1·68=99·31. Found at the Silver Islet Mine, Lake Superior. Named from the Indian word *animikie*, meaning *thunder*, whence Thunder-Bay.—*Ibid.*, Feb. 22.

Randite. Occurs as a lemon-yellow incrustation on granite from Philadelphia. Earthy, probably crystalline. Hardness =2·3. An analysis upon ·047 gr. gave:—CaO 32·50, U_2O_3 31·63, H_2O 6·53, (CO_2 29·34 by difference) =100. The formula deduced is $Ca_4U_2C_6O_{20}+3H_2O$, which, in case it is confirmed by further examination, would place it near liebigite. Named after Mr. Theodore D. Rand, of Philadelphia.—*Proc. Acad. Nat. Sci. Philadelphia*, 1878, 408.

Hannayite, Newberyite. Two new phosphates from the guano of the Skipton Caves, Victoria, described by vom Rath. Hannayite crystallizes in the triclinic system; cleavage basal perfect, less perfect parallel to the two prismatic planes. Specific gravity =1·893. The mean of two analyses gave: P_2O_5 45·70, MgO 18·90, Ammonia 8·09, H_2O 28·20=100·89. The loss of water between 100° and 120° is 21·08 per cent.

Newberyite crystallizes in the orthorhombic system. The cleavage is brachdiagonal perfect, also basal imperfect. An analysis gave: P_2O_5 41·25, (MgO 23·02 by difference), H_2O 35·73=100·00. The formula deduced is $Mg_2P_2O_7+7aq$.—*Bull. Soc. Min. France*, 1879, 79.

III. Botany and Zoology.

1. *Catalogue of the Davenport Herbarium of North American Ferns, Massachusetts Horticultural Society;* by George E. Davenport. Salem, 1879. 8vo, pp. v, 42.—This is a very full catalogue of the known Ferns of the United States and British America, and contains the names of collectors and donors, and the localities of all the North American ferns in the very rich collection which Mr. Davenport has presented to the Massachusetts Horticultural Society. The genera and species are arranged very nearly in the same order as that of Mr. Robinson's check-list, and that is based on the system of Mettenius. The Catalogue contains the names of 32 genera and 142 species, all but one or two of which are represented in the Herbarium by North American specimens. A good many excellent notes on critical forms are scattered through the book, and no student of our Ferns can afford to neglect its pages. *Pteris serrulata* appears here for the first time as a North American species, having been discovered growing spontaneously in the vicinity of Mobile, Alabama, by Mr. Charles Mohr of that city. *Polypodium pectinatum* and *Adiantum tenerum* are also for the first time announced as Ferns

of the United States. Specimens of the former, the name of which had not been definitely settled, had been sent to Mr. Chas. E. Faxon to draw for the *Ferns of North America*, and that gentleman noticed the difference between them and his own specimens of *P. Plumula*. He brought the matter to the attention of the writer of this notice, who then decided to call the large form *P. pectinatum* Linn., and the smaller one *P. Plumula*. The *Adiantum* had been for a year or more in the hands of Mr. Davenport and Mr. Faxon, as unchallenged *A. Capillus-Veneris*, and was first pronounced something different from that species by Mrs. Dr. Barnes, of Syracuse, who obtained fronds from living plants brought from Ocala, Florida, by Mr. Christian Beh, in March, 1877.

Mr. Davenport retains *Pellæa brachyptera*, of Baker, as a distinct species, and is no doubt right in doing so. Within the last few years it has been sent in by many collectors, and keeps its distinctive characters even better than some other recognized Californian Ferns. *Aspidium Bootii* of Tuckerman, is maintained as a distinct species, and so is *A. Americanum*, of Davenport, the *A. spinulosum* var. *intermedium* of Gray's manual.

An appendix gives a list of doubtful and excluded species, and one introduced species, *Adiantum cuneatum*, which was found "Established at Valley Falls, Rhode Island" by Mr. J. L. Bennett, who will doubtless give full particulars of his discovery in his forthcoming "*Plants of Rhode Island.*" [It seems hardly worth while to introduce into a work like this a mere escape from cultivation, doubtless transient.] The Catalogue is beautifully printed, and contains very few typographical or other errors to mar its excellence. D. C. E.

2. *Cane-sugar in Early Amber Cane.*—Professor GŒSSMANN (Fifteenth Annual Report of Mass. Agricul. College) comes to the following conclusions respecting the proportions of cane and grape sugar in this variety of Sorghum at different periods of its growth: 1st. Grape-sugar appears in the cane at an early stage of its growth, and increases slowly to from three to four per cent before cane-sugar is formed; 2d. Cane-sugar is first noticeable at the time when the flower stalks become visible above the leaves, and its amount increases steadily until the seeds are of full size, yet still soft; 3d. The relative proportion of grape-sugar to cane-sugar at any time before the hardening of the seeds, do not exceed 3·16 per cent of the former to 8·49 per cent of the latter, in the majority of cases it was about three to seven. G. L. G.

3. *Number of the digestive glands in Dionæa.*—Léo Errera, thinking it would be physiologically interesting to know the number of glands to each flytrap of *Dionæa*, made a careful examination in this regard. He found an average of sixty to each square millimeter, or about 8,000 to each leaf. See Comptes-Rendus des Sèances de la Soc. Roy. Bot. de Belgique, April, 1879, p. 56.

A. G.

4. *Characeæ Americanæ, Illustrated and Described by* TIMOTHY F. ALLEN, A.M., M.D., etc.—This work is published by

the author himself, in very handsome style, each part consisting of one leaf or page of letter-press and a plate, in quarto form. The plate is printed in green color. The second fascicle has also a wood-cut in the letter-press. It is evident that Dr. Allen is making this a labor of love, regardless of expense. He announces that his work "will be issued each month, and will include every species and variety known to American waters. The author will be happy to send the work to botanists and receive in return the *Characeæ* of their collecting, to the number of fifty specimens of each variety." Directions for collecting and preparing specimens of *Charæ* are appended to the announcement on the cover. Each plate gives a view of a specimen in the natural size, a fructiferous portion magnified, and a cross-section of stem. The general view of the plant is particularly good. The magnified portions have a certain stiffness and solidity, which will probably be got rid of in future trials. Dr. Allen should be, and we may be sure will be, encouraged to carry on to completion an undertaking which will make an obscure and neglected branch of botany popular in this country, and which may incite to new discoveries. A. G.

5. *Malesia; Raccolta di Osservazionie Botaniche interno alle Piante Dell' Archipelago Indo-Malese e Papuano, da* ODARDO BECCARI. Vol. I, fasc. 1–3. 1877–78. 256 pp. tab. I–XV, 4to. Geneva.—Dr. Beccari, the successful explorer of New Guinea, Borneo, etc., and now the Director of the Royal Museum at Florence, is publishing in this fine work his botanical discoveries and those of Signor D'Albertis as fast and as far as he is able to elaborate them. Thus far the articles are all by his own hand; and the work bids fair to be one of the most important of recent contributions to systematic botany. It is not often that we can have such an interesting accession to Phænogamous Botany as is Beccari's *Corsia ornata*, a small root-parasitic plant of New Guinea (dedicated to the Marquis Corsi Salviati), which may be speculatively viewed as a sort of survival, representing a type from which *Orchideæ* and *Burmaniaceæ* have proceeded. The 6-phyllous perianth has five similar and lorate divisions, and a sixth much larger and dilated one which bears a nectary within; but this is the posterior one of the outer series. The andrœcium has its full compliment of six wholly normal and similar antheriferous stamens, with the inner series of these the three carpels of of the ovary normally alternate; and the large placentæ are carried inward on imperfect dissepiments, thence their lamellæ are revolute toward the back of the cells.

The first fascicle is devoted to Palms; the second to these and to *Icacineæ*, *Menispermaceæ*, *Monimiaceæ*, etc.; with new genera in all; the third has an excursus on *Nepenthes* and its distribution, and describes new *Burmanniaceæ*. A. G.

6. *On the Self-fertilization of Plants;* by the Rev. GEORGE HENSLOW, M.A., F.L.S., etc. A memoir in the Transactions of the Linnean Society of London, ser. 2, Bot. vol. i. pp. 318–398, with a plate. Read Nov. 1, 1877. Issued 1879.—This paper is

elaborate, mostly able as well as ingenious, in all respects considerable, and unconvincing. Its thesis is, the Darwinian "Nature abhors perpetual self-fertilization," read backward. It concludes that, "not only are the majority of plants self-fertilizing, but that those which are exclusively so propagate abundantly and with extraordinary rapidity, are best able to establish themselves in foreign countries, as, being quite independent of insects, they run no risk of extermination on that score; . . . that, so far from there being any necessarily injurious or evil effects resulting from the self-fertilization of plants in a state of nature, they have proved themselves to be in every way the best fitted to survive in the great struggle for life." The hypothesis is also advanced "that they are all degraded forms," and that *therefore* "their ancestral life-history is a longer one than that of their more conspicuous and intercrossing relations." We fail to see how this follows, except upon the assumption that the earliest phænogamous plants had the most highly organized blossoms; and that would not accord with vegetable paleontology.

Mr. Henslow rejoices that he has one staunch supporter; "for, as has been seen, Mr. T. Meehan has arrived at the same conclusion;" and indeed he builds not a little upon facts supplied by Mr. Meehan's observations. He cites the latter's "admirable paper, which was reproduced in the 'Gardner's Chronicle' for Sept. 11, 1875, and is in fact an 'apology' for self-fertilization." As he then marshalls twenty reasons for believing particular plants to be normally self-fertilizing, and nineteen "chief facts which may be regarded as occurring correlatively with self-fertilization, some being actual causes which directly or indirectly bring it about," it would appear that it is no longer self-fertilization, but rather the existence and *raison d'être* of cross-fertilization that stands in need of apology, or of explanation.

He freely concedes that the flowers of many plants, and some whole orders, are so constructed that intercrossing is for them a necessity; also that most of those which are believed "to be normally self-fertilizing" because they can and do fertilize themselves habitually," yet "may in some cases be cross-fertilized by insects." It is admitted that the structure of the latter is *adapted*—most variously and wondrously adapted—to being fertilized by particular insects. As this comes to pass in plants and flowers of the highest organization and greatest specialization, Darwin and his school conclude that this is a most advantageous outcome, and means some real good to the species; that when this is accompanied with a loss of self-fertility, it is the loss of something no longer useful, something better than self-fertility having taken its place. But Mr. Henslow, reading this the other way, having determined "that self-fertilization is *per se* a decided advantage," and free from injurious liability, comes to regard intercrossing as merely "a compensatory process for the loss of self-fertility."

But how and why did this "compensatory process come to

pass? It is conceived on both sides that flowers were "primordially inconspicuous." (To this Henslow adds hermaphrodite and self-fertile, but that need not here come into account.) Both agree that insects have mainly determined their conspicuousness. Darwin says this has been determined through natural selection by the survival of the more and more conspicuous variations, correlated with their producing something good for the insect of which the coloration was a sign, and that the preferential survival of the more showy and attractive was a consequence of some benefit of the intercrossing. Henslow propounds the view that insects have determined the conspicuousness more directly, and not by benefiting but by irritating the flowers. "These, by being greatly stimulated by the repeated visits of insects, tend to become hypertrophied. Hence the corolla enlarges, becomes more brightly colored, the nectariferous organs increase the quantity of secretion, and the stamens develope more pollen. Such being the case, nourishment is withheld from the pistil, which is delayed in its development; consequently such a flower is very generally proterandrous." Mr. Darwin might accept this as an ingenious conception of the way the specialization comes about, still insisting on the advantage of the resulting intercrossing—" or else the thing would hardly come to pass," as the poet has it. And Mr. Henslow's hypothesis has to be supplemented to account for proterogyny, which is not much less common. But Henslow's supposed process works evil instead of good, and is therefore utterly anti-Darwinian and "dysteleological." For the result is a disturbance of the equilibrium and proper correlation between the andrœcium and gynœcium; and this, carried further, should upon this view result in the monœcious and diœcious states. So, accordingly, the cross-fertilization which comes into play in the case of separated sexes, and in that of self-sterile hermaphroditism, is not for any good there is in it *per se*, but because it may no better be. And all the elaborate, exquisite, and wonderfully various modes of adaptation of flowers to insects are only ways of repairing the damages inflicted upon blossoms by insects through their persistent visits! Did Mr. Henslow ever ask himself the question why the sexes are separate in animals?

The conclusion which Mr. Darwin had helped us to reach is, that intercrossing should be regarded as the aim in nature and on the whole most beneficial, and self-fertilization as a safe-guard against the risks of crossing; that most hermaphrodite flowers have the advantage of both, the latter for immediate sureness, the former for ultimate benefit. Upon the new view, self-fertilization is the aim and the consummation, and cross-fertilization at best a succedaneum. By it insects may repair the damage they have caused to blossoms through endowing them with " the fatal gift of beauty," and stimulating their organs of secretion; and by it the winds may bring chance relief to those which, at length abandoned by their spoilers, have lost this attractiveness and fallen to the degradation of unisexuality. For these last, as has

already been stated, are hypothetically regarded as degraded from higher floral types.

We are bound to glance at some of the considerations which are adduced in support of this thesis. They are multifarious and of unequal value. As has occurred in other cases, so here also, the weightiest objections to Mr. Darwin's view are those which he has himself brought out, namely, the fact that, as tested experimentally under cultivation, while some plants are much increased in vigor and fertility by artificial intercrossing, others are not sensibly benefited; and that the benefit derived in marked cases is not cumulative, but reaches its maximum in two or three generations. And even close breeding under cultivation occasionally gives rise to very vigorous and fully prolific self-fertile races. Then many plants are fully self-fertile in nature, and it is not proved that any such have lost or are in the way of losing either fertility or vigor through continued inter-breeding. But, before drawing from this the conclusion that cross-fertilization is of little or no account in nature, it should be remembered that bud-propagated races are in similar case. Races exist which have been propagated only from buds for hundreds of years, with seemingly undiminished vigor, and there is no proof that any one has succumbed under the process. But for all that we do not doubt that sexual reproduction contributes something to the well-being of the species, besides facilitating its dispersion. Again, no one questions the necessity of fertilization by pollen to the production of embryo in the seed; yet, even in this, the necessity is not so imminent but that some embryos may originate without it. (See preceding volume of this Journal, p. 334.)

In short, the facts brought out by Darwin and others, and all the considerations of the present essay, are best harmonized by the conception which the former has consistently maintained, namely, that an occasional cross suffices to secure the benefit of intercrossing, whatever that may be. Nothing yet appears which seriously disturbs our conviction that just this is what nature generally provides for.

Mr. Henslow's proposition, "The majority of flowers are self-fertile," is doubtless true in the sense that they are capable of self-fertilization, and is not improbable in the sense that they "can and do fertilize themselves habitually." But his inference that the majority of flowers, or that any flowers, actually propagate for a series of generations by self-fecundation, or that a cross if it occur is "exceptional," and of no account, is surely unwarranted by the evidence which he has adduced.

Occasionally the reported facts will not bear scrutiny. *Gentiana Andrewsii*, it is said, never opens at all in America. It opens in sunshine in the middle of the day here in New England. And while looking at closed flowers we have seen a humble bee emerge from one. We have, in this Journal, shown how it is that self-fertilization is impossible during the first three or four days of anthesis, but neatly practicable afterwards. It is rash to

infer (as on p. 330) that papilionaceous flowers which shed their pollen early in proximity to the stigma are therefore self-fertilized. In most of the cases adduced the pollen is not lodged upon the stigma, but upon the style below it, and the adaptations for intercrossing, though the mechanism be different, are as explicit as in the analogous case of Campanula. "Fremont pathetically describes the solitary bee that rested on his shoulder at the top of Pike's Peak." The pathos is wasted as respects all but this particular bee; for the entomologists find the alpine region of the Rocky Mountains to be as well stocked with flying insects as are alpine regions in other parts of the world. They do not superabound, but if from the alpine flora we subtract the evidently entomophilous and the anemophilous blossoms, the remainder will be nearly nil. And as to the correlation of this comparative scarcity of insects with the marked conspicuousness of blossoms, this is the way the lesson is read by a most eminent physiologist: "Even the glowing hue of alpine flowers is accounted for by the attraction which brighter-colored individuals exercise upon the insects, scarce in those heights and necessary for fertilization."

One or two of the author's own observations are perhaps to be revised. "*Gaura parviflora* . . . has no corolla and is cleistogamous, in that it is self-fertilizing in bud, as I found in specimens growing at Kew." Were they not imperfectly developed blossoms, perhaps late in the season? Here the flowers open freely and have rose-colored petals. If he will examine fresh specimens of *Scrophularia*, it will soon be clear that his idea of their self-fertilization (p. 371) is a mistake. It is a mere slip in the Genera Plantarum through which abortive stamens are attributed to the cleistgamous flowers of *Epiphegus*. The authors evidently meant to describe the case just as Mr. Henslow found it to be, but used a wrong word.

"Weeds are probably all self-fertilizing or anemophilous. A weed is simply an unattractive plant, and possessing no feature worthy of cultivation." It may be as difficult to define "a weed" as to define "dirt." But, turning to the Handbook of the British Flora, we find, as we expected, that the showy Corn Poppy, Cockle, and Larkspur are denominated weeds. Why weeds should possess the vigor and gain the predominance which they do is a large question, to which other solutions have been offered than that the one which is in this essay very plausibly maintained. We cannot take up the topic here; but, without acceding to his general proposition, we are much disposed to agree with the author in this essay, as respects some of them, that aptitude for self-fertilization may have given them the advantage which has determined their wide dispersion.

The insistence upon the importance of self-fertilization is what gives this essay its value. As a whole it fortifies the proposition, well laid down by Herman Mueller, which Mr. Henslow cites:—"that, under certain conditions, the facility for self-fertilization is most advantageous to a plant, while, under other conditions, the

inevitableness of cross-fertilization by the visits of insects is the more advantageous." But this is not our author's thesis. It comes to this: the plan of nature is either cross-fertilization supplemented by close-fertilization, or close-fertilization tempered by cross-fertilization. As restricted to plants the difference is not wide. Regarded generally, the Darwinian axiom is still best sustained. A. G.

7. *On the causes of the change in form of Etiolated Plants;* by Professor GODLEWSKI, Dublany (Poland). Bot. Zeit. 6, 1879. —In 1873, Professor Godlewski published in Flora an account of his investigations respecting the formation of starch in chlorophyl grains. In that memoir he stated that the changes in form which plants undergo in darkness are not due to the suspension of the assimilative process. In 1875 and 1877 he published in the Polish language two short notices of his further observations upon this subject, and which he now fully recounts in the present paper. Only the first series of his later experiments will be referred to now, namely, those bearing upon the question as to the relation of the assimilative process to the change of form in growing plants deprived of light. It is a general rule, to which there are some exceptions, that internodes grown in the dark are longer, and leaves are smaller than those which develope in sunlight. In Pringsheim's Jahrbücher f. wiss. Botanik, vol. vii, p. 213, Dr. G. Kraus has sought to explain the latter fact by the hypothesis that it is chiefly out of assimilated matter freshly formed in growing green leaves themselves that they expand to their full size, and hence the diminutive size of etiolated leaves is thought by him to be directly dependent upon the absence of the assimilative process.

In Professor Godlewski's experiments germinating plants were cultivated in an atmosphere deprived of its carbonic acid, some of them in light, others in perfect darkness, but under similar conditions of temperature and moisture. It was found that when the plantlets had exhausted the food stored in the seed, and had ceased to grow, the total weight of dry organic matter was the same in the green and in the etiolated plants. The plantlets which had grown in the light but in air free from carbonic acid, and where assimilation could not take place, did not bear the slightest resemblance in form to etiolated plants. They were of perfectly normal habit. G. L. G.

IV. ASTRONOMY.

1. *Orbits of the binary systems, μ Herculis and* 298 *Struve;* by W. BEEBE.—The double star μ Herculis had been observed since 1858, and has shown a change of about 180° in the position angle though the observations, twenty-eight in number, and by twelve different observers, exhibit large discrepancies and are not all trustworthy.

The orbit was computed by Herschel's first method and agrees with the interpolation curve quite closely. The corrections to E,

T and P., obtained by Klinkerfue's first method did not, however, improve the agreement. The eccentricity is somewhat uncertain and the periodic time probably too large. The observations for 298 of O. Struve's catalogue are thirteen in number and agree tolerably well. It has been observed since 1843, and the position angle up to 1878 had changed about 130°. The orbit was computed by Herschel's second and Klinkerfue's first method. The orbit however is not definitive.

For the observed places used I am indebted to Mr. Burnham, who kindly collected for me all the available material.

	μ Herculis.	298 O Σ.
T	1873·4	1881·7
P	225· years	79·2
☊	34°	5° 58′
π-☊	143° 52′	357 17
i	37 10	66 35
e	·731	·585
a	2″·69	1″·23

New Haven, April 5th.

2. *Report of the Observations of the Total Solar Eclipse, July* 29, 1878, *made at Fort Worth, Texas.* Edited by LEONARD WALDO, Assistant at the Observatory of Harvard College. 60 pp. 4to, with 4 plates.—The Fort Worth Eclipse party consisted of Messrs. Waldo, Willson, Rees, Pulsifer and Seagrave, a volunteer party whose special object it was to record such phenomena as might aid in establishing the correct theory regarding the solar corona. Observations were made with the naked eye, the telescope, the spectroscope, the polariscope, and photographs of the corona were taken both with and without double refracting prisms. Professor Pickering and Mr. Waldo consider that the double image photographs imply tangential polarization of the light of the corona.

Mr. Pulsifer observed the reversal of the lines of the spectrum with the bright lines (except C) shortened at each end. He infers therefrom that his slit extended beyond the reversing layer on each side. He hence infers a minimum thickness of the reversing layer of 524 miles. H. A. N.

3. *Catalogue of Stars observed at the United States Naval Observatory, during the years* 1845–1877, *and prepared for publication by* Professor M. YARNALL, U. S. N., by order of Rear Admiral JOHN RODGERS, U. S. N., Superintendent. Second edition, revised and stereotyped, 280 pp. 4to. Washington, 1878.—The author of this Catalogue of Stars, Professor Yarnall, died on the 27th of February, 1879; he lived to correct the last proof sheets of this work, but not to see the volume in its completed form. This catalogue includes all the work done at the Observatory with the old instruments, and thus, as the author remarks, forms an epoch in the history of the Observatory. It is a work of high intrinsic excellence and is of especial interest as containing the results of the life work of a most accurate, patient and untiring observer.

4. *Astronomical and Meteorological Observations made during the year* 1875 *at the United States Naval Observatory*, Rear Admiral C. H. DAVIS, U. S. N., Superintendent. Published by authority of the Hon. Secretary of the Navy. 4to. Washington, 1878.—In addition to the description of observations made at the Observatory in 1875, which cover 560 pages of the volume, it also contains three Appendixes; one of them is entitled Researches on the Motion of the Moon made at the U. S. Naval Observatory, Part I, by Professor Simon Newcomb. The great work undertaken by Professor Newcomb has as its object the re-investigation of the subject of the Moon's motion, with a view to ascertaining the cause of the deviations of the observations from Hansen's Tables. The part of the work now published contains a reduction and discussions of observations of the moon before 1750, involving the use of much material hitherto but little known. The remaining part, not yet completed, will contain a computation of the action of the planets and the deduction of the mathematical theory of the inequalities of long period in the moon's mean motion.

5. *On the Spectrum of Brorsen's Comet;* by W. H. M. CHRISTIE. —With reference to Professor C. A. Young's Note on the Spectrum of Brorsen's Comet, it may be of interest to mention that observations made at the Royal Observatory, Greenwich, confirm his conclusion as to the coincidence of the brightest band in the comet spectrum with the green band of carbon.

We were not able to examine the comet's spectrum till April 17, as the Great Equatoreal was in the workmen's hands till that date for alterations required to allow of the more convenient use of the spectroscope. On that evening, and again on April 19, the comet's spectrum was repeatedly compared by Mr. Maunder and myself, with the spectrum of alcohol taken in a vacuum tube. The less refrangible edge of the brightest comet-band coincided as exactly as could be determined with the corresponding edge of the green carbon-band at 5,200, but the comet-band was very much wider, extending two-thirds of the way toward F (i. e., about 200 tenth-meters), and covering the carbon-band at 5,200 (about 30 tenth-meters broad) and the two following fainter bands at 5,100 and 5,020. The comparisons were made on April 17 by the help of an occulting bar, and on April 19 with Hilger's bright-line micrometer, illuminated by red light. With the latter, readings for the comet- and carbon-bands respectively, agreed within half a tenth-meter. The half prism spectroscope with a dispersion of 10° from A to H (equivalent to two prisms of 60°) was used on the 13 inch equatoreal. From spectroscopic observations of the carbon compound, printed in the volume of Greenwich Observations, 1875, it appears that the bands in the spectrum of alcohol are identical with those in the spectra of olefiant gas, and of carbon monoxide and dioxide.

A second band was seen in the orange of the comet's spectrum approximately coincident with the carbon band about 5,600.

This band was of about one-fourth the brightness of the principal band.

The results on April 17 were obtained without a knowledge of Professor Young's work, and thus afford an independent confirmation of his conclusion.—*Nature*, May 1.

Royal Observatory, Greenwich, April 21.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notes on Pagosa Springs, Colorado;* by Lieut. C. A. H. McCAULEY, Third Cavalry, Assistant Engineer, U. S. A. 27 pp. 8vo. Report to the Secretary of War, Feb., 1879; printed by order of Congress.—The Pagosa Springs are situated in the valley of the San Juan river, southern Colorado, on the road from Tierra Amarilla, New Mexico, to the Animas region. The springs have been long known and used by the Ute Indians; they received from them their name *Pah-gosa*—from *pah*, water, and *gosa*, boiling. The group of hot springs occupies an area of about twenty-one acres on the western side of the River. Lieut. McCauley describes nineteen of these, and in addition several cold springs forming an independent group; they are situated in an area of the Cretaceous formation. The largest hot spring has a pear-shaped crater sixty-nine feet long and forty-five feet wide, the depth not determined. An apparent ebullition goes on constantly, but it is gaseous and not due to boiling, the waters rising charged with hydrogen sulphide and carbon dioxide. The temperature of this spring was found to be 141° F., that of the river being 40° F., and the highest air-temperature being 49° (December); the temperature at the exits into the river—the outflow is subterranean—was 127° F. The waters contain, besides the gases, chiefly calcium carbonate and sodium sulphate, with smaller quantities of sodium chloride, sodium, magnesium and lithium carbonates, and potassium sulphate. The deposition of solid matter goes on quite rapidly, stalactites and stalagmites, consisting chiefly of calcium carbonate and sodium sulphate, being formed within the pools.

The temperature of the water in the other springs varied mostly between 135° and 140°, though several of them had temperatures, of only 101°–110°. The cold springs are south of the main spring, on the opposite bank of the river and about half a mile distant; their temperature differs but little from that of the air. Lieut. McCauley's Report contains a series of interesting wood-cuts showing the topographical relations of the country about the springs, and also the details in their structure.

2. *Notes by a Naturalist on the Challenger*, being an account of various observations made during the voyage of H. M. S. "Challenger" around the world in the years 1872–1876, by H. N. MOSELY, M.A., F.R.S., Fellow of Exeter College, Oxford, Member of the Scientific Staff of H. M. S. Challenger. 606 pp. 8vo., with a map, two colored plates and numerous woodcuts. London, 1879 (Macmillan & Co.).—These notes make a volume full of facts of interest, popular as well as scientific, relating to the countries and

people visited, icebergs, corals and coral reefs, the habits and nature of some of the stranger animals and plants of the sea and land, and on geological, anthropological and other topics; and they are presented in the direct and lucid style that bespeaks the faithful scientific observer. The author is an able naturalist, and has published many very valuable papers (partly in the Transactions of the Royal Society) as the results of careful work during the cruise and of thorough microscopic investigations since, relating to the structure of *Millepores*, the Alcyonarian relations and structure of *Heliopora cœrulea*, the structure of the *Stylasteridae*, on *Corals*, *Actinaria*, *Planariæ*, and other zoological subjects, besides Botanical notes in the Journal of the Linnæan Society.

3. *Report of the National Academy of Sciences.*—At the meeting of the National Academy of Sciences held in Washington, April 15th to 19th, 1879, the following papers were read:

C. S. PEIRCE.—Ghosts in the diffraction spectra; Comparisons of the meter with wave lengths; On the errors of pendulum experiments, and on the method of swinging pendulums proposed by Mr. Faye; On projections of the sphere which preserve the angles.

HENRY DRAPER.—Confirmations by spectrum photographs of the discovery of oxygen in the sun.

E. C. PICKERING.—On the eclipses of Jupiter's satellites; On two new forms of micrometers.

ALFRED M. MAYER.—On a new form of heliostat.

J. E. HILGARD.—Report on the progress of the international bureau of weights and measures; An account of geodetic acts determined by the Coast Survey in relation to the figure of the earth.

SIMON NEWCOMB.—On the recurrence of solar eclipses.

H. A. NEWTON.—On the influence of Jupiter upon bodies passing near that planet.

S. WEIR MITCHELL.—On tho relations of neuralgic pains to storms and the earth's magnetism.

C. F. CHANDLER.—On a new polariscopic method for the detection and estimation of dextro-glucose in the presence of cane sugar and inverted sugars.

H. L. ABBOTT.—On the ignition of high tension fuses.

ELIAS LOOMIS.—The winds on Mount Washington compared with the winds near the level of the sea.

E. W. HILGARD.—The lœss of the Mississippi, and the Æolian hypothesis.

JOSEPH LECONTE.—The extinct volcanoes about Lake Mono and their relation to our glacial drift.

J. S. NEWBERRY.—On the great silver deposits recently discovered in Colorado, Utah, and Nevada.

G. J. BRUSH.—On a mineral locality in Fairfield County, Connecticut.

A. AGASSIZ.—Report on dredgings in the Caribbean Sea by the Coast Survey steamer Blake, Commander John R. Bartlett, United States Navy.

C. V. RILEY.—On the hybernations and migrations of *Aletia argillacea* (the parent of the cotton-worm).

S. H. SCUDDER.—The Palæozoic cockroaches.

E. D. COPE.—On the extinct species of the Rhinoceros and allied forms of North America.

H. MITCHELL.—On the physical hydrography of the Gulf of Maine.

G. K. GILBERT.—On the stability and instability of drainage lines.

A. GRAHAM BELL.—On vowel theories considered in the light of recent experiments with the phonograph and phonautograph.

F. A. P. BARNARD.—Report of the Committee on Weights, Measures, and Coinage.

Professor William B. Rogers was elected President in place of Joseph Henry, deceased. The following new members were elected: Cleveland Abbe, J. W. Gibbs, W. G. Farlow, H. C. Wood.

APPENDIX.

Art. LXIII.—*Polydactyle Horses, Recent and Extinct;* by Professor O. C. Marsh.

It is said that the aborigines of this country, when they first saw the horses brought over by the Spaniards, named the new animal "the beast with one finger nail." Certainly, the single hoof on each foot is the most marked characteristic of the modern horse, and one on which some of his most valuable qualities depend. The nearest living allies of the horse are the ass and the zebra, and they possess the same pedal peculiarities.

In addition to each main digit of the ordinary horse, however, the anatomist finds concealed beneath the skin two slender metapodial "splint bones," which are evidently the remnants of two other toes, originally possessed by the ancestors of the horse. It is an interesting fact that these splint bones are sometimes quite fully developed, and may even support extra digits, which are much smaller and shorter than the main foot. As these small hooflets are usually regarded as a serious detriment to the animal, they are generally removed from the colt soon after birth, but in such cases the enlarged splint bones not unfrequently indicate in the adult their former existence.

Numerous cases of extra digits in the horse have been recorded, and in nearly all of them a single lateral hooflet was present on one of the fore legs. In most instances the occurrence was noted chiefly on account of its rarity, and no record was made of the exact position of the extra hoofs with reference to the main digit, nor of the significance of these useless appendages. Since the attention of the writer was called to the subject, a few years since, he has ascertained that these supernumerary digits are much more common in the horse than has been supposed, and in many cases they appear to indicate a reversion to an early ancestral type.

The figures given below represent, (1) the foot of the modern horse in its normal condition, with the splint bones rudimentary; (2) the foot abnormally developed, with one splint bone bearing a small hooflet; and (3) the foot of an extinct three-toed ancestor of the horse. The feet are all from the left side, and the numbers attached indicate the different digits, counting from the inside. The first and fifth, corresponding to the thumb and little finger of the human hand, are wanting in these figures. A specimen similar to that represented in figure 2 is preserved in the Museum of Yale College.

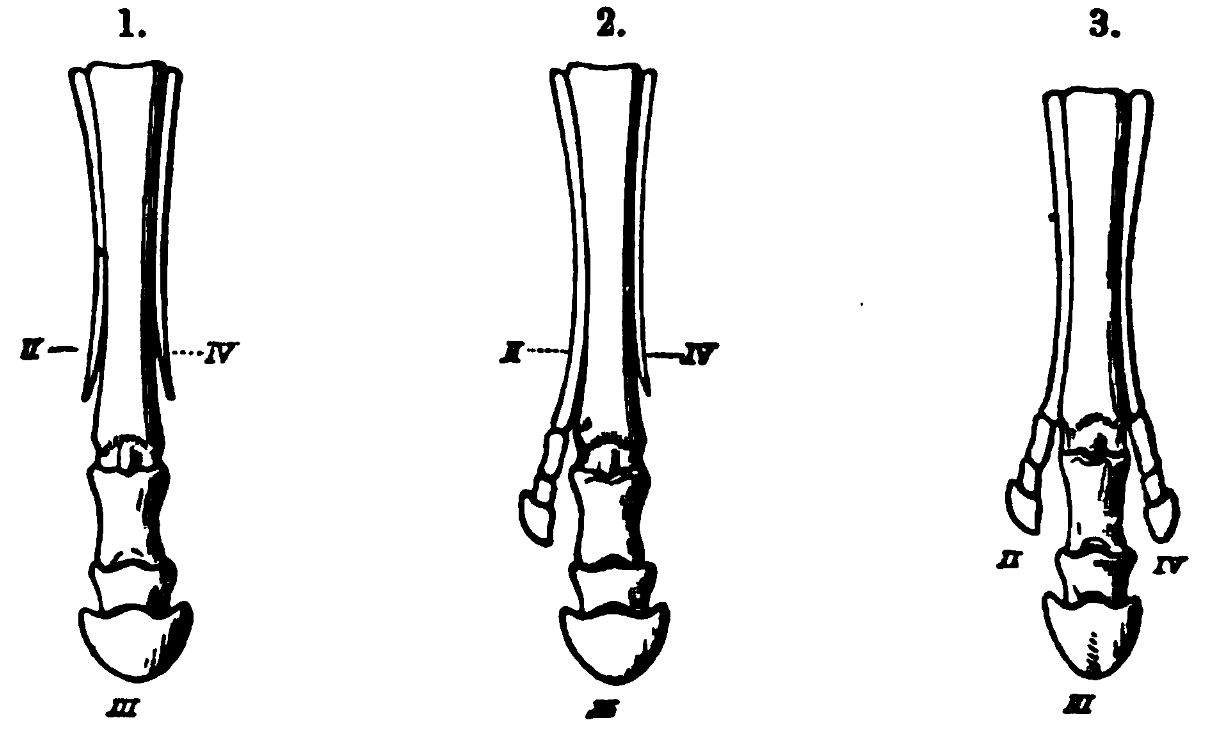


Figure 1.—Fore foot of Horse (*Equus*).
Figure 2.—Fore foot of Horse with extra digit.
Figure 3.—Fore foot of *Hipparion*.

The first recorded instances of extra digits in the horse, known to the writer, are two mentioned by George Simon Winter, in his famous book on Horses, published near the beginning of the last century.* One of the horses referred to and figured in this work was "eight-toed," having a small extra digit on the inside of each foot (p. 134, Plate 21 F.). Winter states that this horse was exhibited in Germany in 1663, and a portrait of it preserved in Cologne. His account was derived from a person who had examined the animal. The other horse described by Winter (page 136, Plate 24), had a small hoof on the inside of each fore foot, and this steed, Winter states, he had not only seen but ridden.

Geoffroy Saint-Hilaire has recorded the fact that he examined a fœtal horse which was polydactyle on the fore feet, the left foot bearing three nearly equal digits, and the right but two.† Owen has described the right fore foot of a horse with a double hoof, the extra digit being on the inner side, answering to

* *De Re Equaria*, Nuremberg, 1703.
† *Annales des Sciences Naturelles*, XI, p. 224. Paris, 1827.

the second digit.* Arloing has figured and described similar specimens.† Leidy has described the right fore leg of a horse with a supernumerary digit on the inner side; and Allen subsequently discussed the same specimen.‡ A number of other instances have been recorded, showing that extra digits are by no means rare in the modern horse.

The most interesting case of this kind examined personally by the writer is the horse represented in figure 4. This animal was on exhibition in New Orleans, in the spring of 1878, and Dr. Stanford E. Chaillé of that city first called the attention of the writer to it, and likewise sent a photograph, from which the cut below was made.

4.

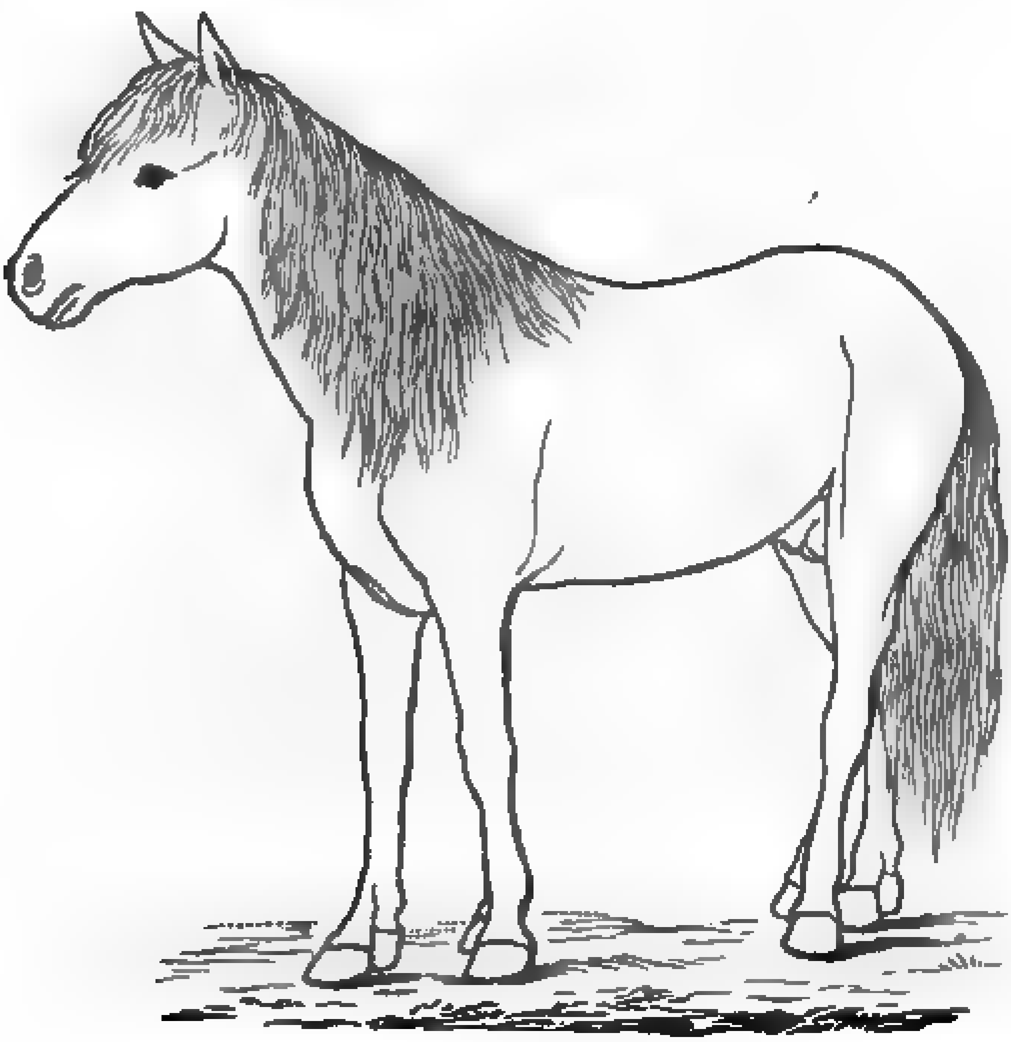


Figure 4.—Outline of horse with extra digit on each foot.

This same horse was subsequently brought to the North, and a few days since was on exhibition in New Haven, Conn., where the writer examined him with some care. The animal is of small size, about ten years old, and is said to have been foaled

* Osteological Catalogue, Museum Royal College of Surgeons, Vol. II, p. 537. London, 1853.

† *Annales des Sciences Naturelles*, VIII, p. 55. 1867.

‡ Proceedings Academy Natural Sciences, Philadelphia. 1871, p. 112, and 1876, p. 92.

in Cuba. He is known among showmen as the "Eight-footed Cuban Horse." With the exception of the extra digits, he is well-formed, and doubtless is capable of considerable speed, although some of the exploits claimed for him may fairly be questioned.

The four main hoofs are of the ordinary form and size. The extra digits are all on the inside, and correspond to the index finger of the human hand. They are less than half the size of the principal toes, and none of them reach the ground. An external examination indicates that the metapodial bone of each extra digit is entire, and at its lower end, at least, is not coössified with the main cannon bone.

There appear to be two phalanges above the coffin bone in each of these digits, which are thus rendered flexible, especially in a fore and aft direction. There was no indication of "interfering" shown on the inner digits themselves, although it is difficult to see how this could be entirely avoided during rapid motion. The splint bone on the outer side of each leg is apparently of the usual shape and size.

Among the instances of recent polydactyle horses, described to the writer by those who have seen them, are two of special interest. One of these was a colt with three toes on one fore foot, and two on the other. The animal recently died in Ohio. Another is a mare, raised in Indiana, and still living, which is said to have three toes on each fore foot, and a small extra digit on each hind foot. In regard to the latter animal, the writer hopes soon to have more definite information.

Besides the instances mentioned above of extra digits in place in the existing horse, there are many cases on record of true monstrosities, as, for example, additional feet or limbs attached to various portions of the body. Such deformities now admit of classification and explanation, but need not be considered in the present discussion.

In reviewing what is now known of extra digits in the feet of the modern horse, the best authenticated instances appear to fall naturally into two groups. The first of these includes digits which are simply cases of reduplication, quite similar to the extra finger occasionally seen in the human hand. Such deformities are apparently a vegetative repetition, the explanation of which has not yet been satisfactorily determined. The second class includes cases where a true digit is formed, the component bones of which are in their normal position, and in proper relation to the rest of the limb. Such instances appear to be clearly due to reversion to some ancestral type. Some digits, which appear at first sight to belong in the first category, may really illustrate the second, but the converse of this is

much less likely to be true. The cases of apparent reversion are of especial interest, and it is important to place on record any information in regard to them, so that they may be compared with extinct allies of the horse.

The cases of extra digits in the horse, so far as at present known, show that these appendages make their appearance more frequently on the fore feet than on the hind feet. This is precisely what a study of the fossil forms of equine mammals would lead us to anticipate.

Another noticeable peculiarity of these extra digits, is their more frequent occurrence on the inside of the main digit, while the outer splint remains rudimentary. This, it must be confessed, is directly opposed to the general law of reduction in the ungulate foot, which, briefly stated, is, that of the five original digits, the first or inner one, first disappears; next the fifth, or outer one; then, the second; and last of all the fourth. The third always remains, as in the horse. It would, therefore, be naturally expected, that when only one additional digit was present, it would be on the outside of the fore foot.

The tendency to interference would seem to be another reason against the retention of the inner digit. Possibly the additional protection which an inside hooflet would receive, might more than counterbalance this influence. Again, the above law is not known to apply to the perissodactyle foot, beyond the first and fifth digits, and if the second digit was originally of greater use than the fourth, and hence was longer retained, an ancestor of the horse may yet be found with the second and third toes alone developed.

In considering these double hoofs of the horse, and with them the well known cleft in the coffin bone of recent and extinct equines, it is important to understand that in no case do they indicate any approach to the true artiodactyle type, as some authors have supposed. The difference between the perissodactyle, or "odd-toed," and artiodactyle, or "even-toed," structure is a profound one, extending to nearly every part of the skeleton, and marking two distinct groups of Ungulates. The number of toes has really nothing to do with the true distinction, and hence the terms in use are especially misleading. The real difference, so far as the feet are concerned, is, that in the perissodactyle type the axis of the limb passes through the middle of the third digit (*Mesaxonia*), while in artiodactyles it is outside of this digit (*Paraxonia*), between it and the fourth.

If, now, we turn back to the early ancestors of the horse for an explanation of the supplementary digits which so often make their appearance, we shall not look in vain, especially in this country. America is the original home of the horse, and

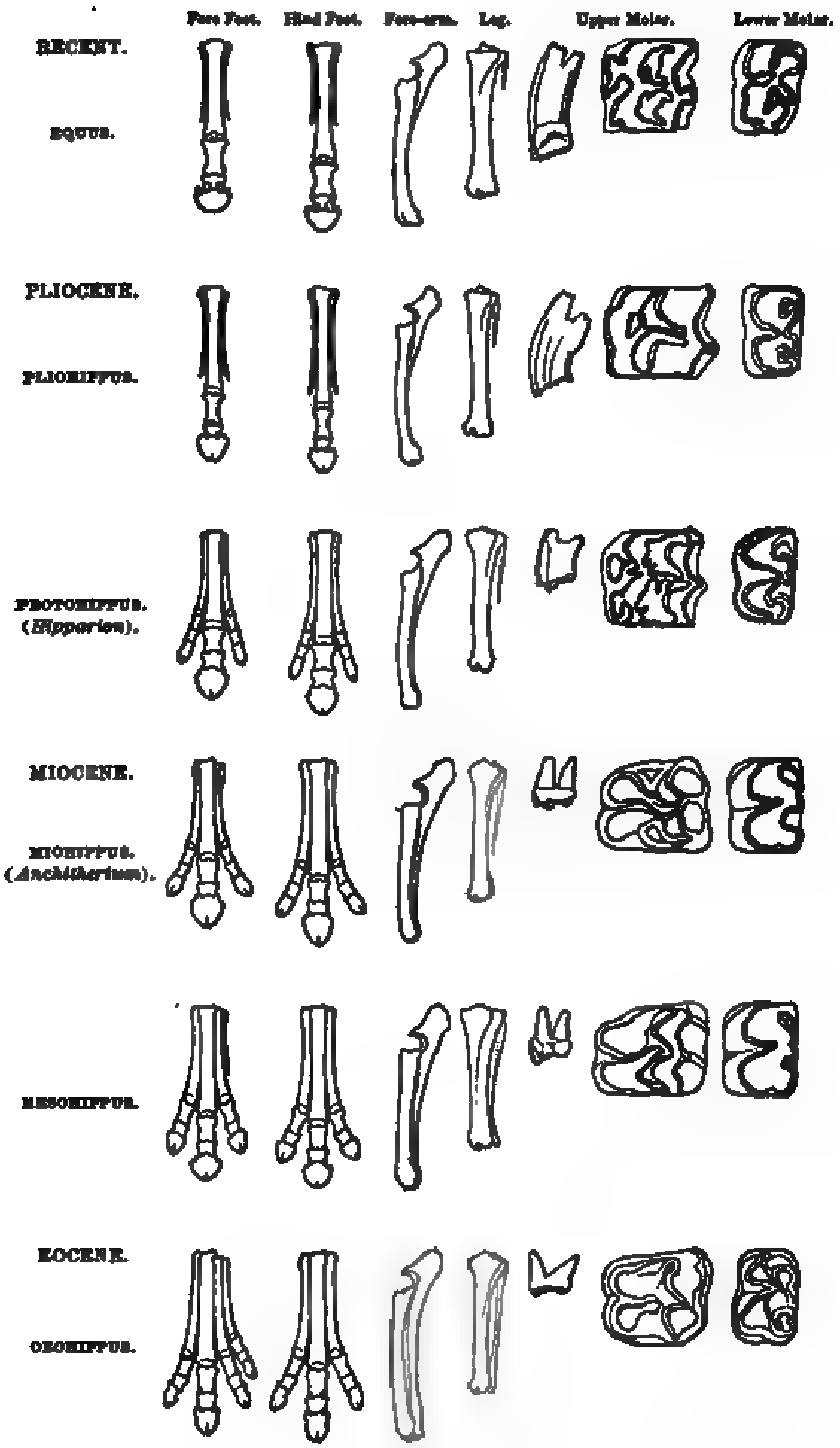
during the whole of Tertiary time, this continent was occupied with equine mammals, of many and various forms. Although all these became extinct before the discovery of this country, their abundant remains mark out the genealogy of the horse in an almost unbroken succession of forms.

If we examine the remains of the oldest representatives of the horse in this country, we shall find that these animals were all polydactyle, and of small size. As the line was continued towards the present era, there was a gradual increase in size, and a diminution in the number of toes, until the present type of horse was produced. In view of the facts mentioned in the preceding pages, it will be profitable to trace the main line of descent in this group, from its first appearance to the present period, and note especially the changes in the number of digits. For this purpose the diagram on page 505 will be instructive, as it records the principal stages in the series, both of the limbs and the teeth as well. This diagram was prepared by the writer for Professor Huxley, who used it first in his New York lectures. The specimens figured are all in the Yale Museum.

The original ancestor of the horse, not as yet discovered, undoubtedly had five toes on each foot. The oldest member of the group now known is the *Eohippus*, which had four well developed toes and the rudiment of another on each fore foot, and three toes behind. This animal was about as large as a fox, and its remains are from the Coryphodon beds, near the base of the Eocene. It is not represented on page 505, as it was found since the diagram was made. In the next higher division of the Eocene, another equine genus, *Orohippus*, makes its appearance. It resembled its predecessor in size, but had only four toes in front and three behind, as shown in the lowest series of the diagram. At the top of the Eocene, a third allied genus has been found (*Epihippus*), which closely resembled *Orohippus* in its digits, but differed in its teeth.

Near the base of the next formation, the Miocene, another equine mammal, *Mesohippus*, occurs. This animal was about as large as a sheep, and had three usable toes and the splint of another, on each fore foot, with but three toes behind, as shown in the diagram. At a somewhat higher horizon, a nearly allied genus, *Miohippus*, has been found, which has the splint bone of the outer or fifth digit reduced to a short remnant. In the Pliocene above, a three toed horse (*Protohippus*) about as large as a donkey was abundant, and still higher up a near ally of the modern horse, with only a single toe on each foot, (*Pliohippus*) makes his appearance. A true *Equus*, as large as the existing horse, appears just above this horizon, and the series is complete.

Yale College, New Haven, May 15th. 1879.



GENEALOGY OF THE HORSE.

INDEX TO VOLUME XVII.*

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.